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PREFACE.

THIS work is offered as a valuable Book of Reference for Mechanics and Manufacturers, trusting they will find information therein that will well repay them.

It is the intention of the Author to produce the most disirable information in the most intelligible form for practical application.

The mechanic who has studied mathematics but little, will find that by studying some of the brief rules herein, he will get a clear comprehension of things that would otherwise be unintelligible to him.

The Author acknowledges his indebtedness to numerous English and American authors for valuable material for tables, etc.

B. F. V.

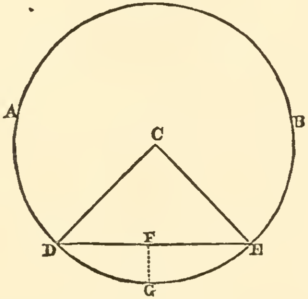
THE

AMERICAN AND ENGLISH MECHANIC.

EXPLANATION OF DIAGRAMS.

To find the Circumference of any Diameter.

Fig. 1.



From the centre C describe a circle A B, having the required diameter; then place the corner of the square at the centre C, and draw the lines C D and C E; then draw the chord D E: three times the diameter added to the distance from the middle of the chord D F E to the middle of the subtending arc D G E, will be the circumference sought.

To find the Area of the Sector of a Circle.

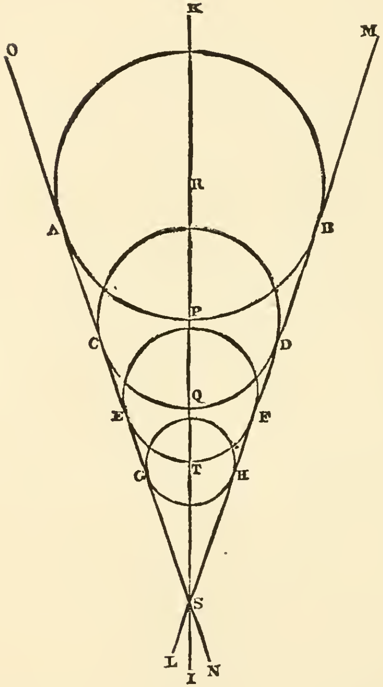
Rule.—Multiply the length of the arc D G E by its radius D C, and half the product is the area.

The length of the arc D G E equal $9\frac{1}{2}$ feet, and the radii C D, C E, equal 7 feet, required the area.

$$9{\cdot}5 \times 7 = 66{\cdot}5 \div 2 = 33{\cdot}25 \text{ the area.}$$

Proportion of Circles.

Fig. 2.



To enable machinists to enlarge or reduce machinery wheels without changing their respective motion.

First, describe two circles A B and C D the size of the largest wheels which you wish to change to a large or small machine, with the centre P of the smaller circle C D on the circumference of the large one A B; then draw two lines L M and N O tangent to the circles A B and C D, and a line I K passing through their centres P and R; then if you wish to reduce the machine, describe a circle the size you wish to reduce it to; if one-half, for example, have the centre Q one-half the distance from R to S and describe the circle E F, and on its circumference T as a centre, describe a circle G H, allowing their circumferences to touch the tangent lines

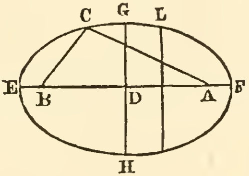
L M and N O, which will make the circle E F one-half the size of the circle A B, and G H one-half the size of C D; therefore E F and G H are in the same proportion to each other as A B and C D.

If you wish to reduce one-third, have the centre Q one-third the distance from R to S; if one-fourth, have the centre Q one-fourth the distance from R to S, and so on. This calculation may be applied beyond the centre R for enlarging machine wheels, which will enable you to make the alteration without changing their respective motion.

To describe an Ellipse, or Oval.

[Simple Method.]

Fig. 3.

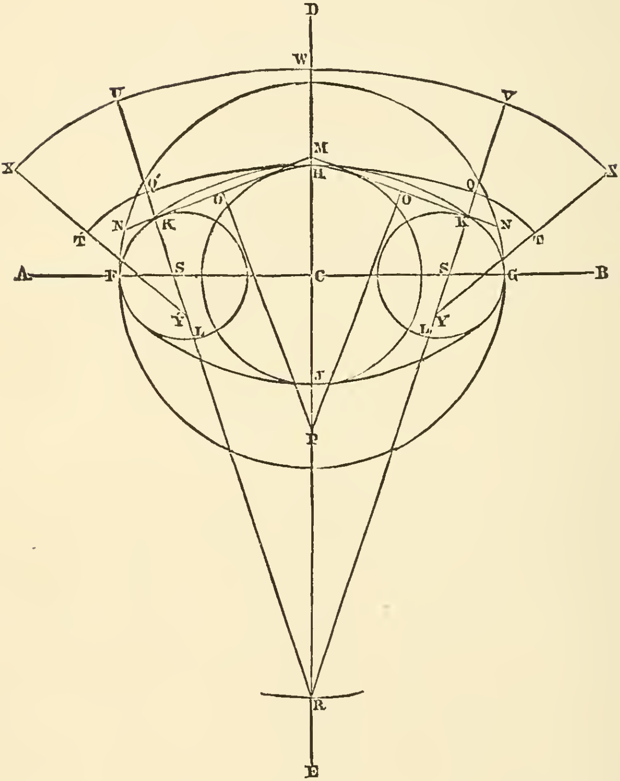


At a given distance, equal to the required eccentricity of the ellipse, place two pins, A and B, and pass a string, A C B, round them; keep the string stretched by a pencil or tracer, C, and move the pencil along, keeping the string all the while equally tense, then will the ellipse C G L F H be described. A and B are the foci of the ellipse, D the centre, D A or D B the eccentricity, E F the principal axis or longer diameter, G H the shorter diameter, and if from any point L in the curve a line be drawn perpendicular to the axis, then will L K be an ordinate to the axis corresponding to the point L, and the parts of the axis E K, K F into which L K divides it are said to be the abscissæ corresponding to that ordinate.

NOTE.—Oval. A curve line, the two diameters of which are of unequal length, and is allied in form to the ellipse. An ellipse is that figure which is produced by cutting a cone or cylinder in a direction oblique to its axis, and passing through its sides. An oval may be formed by joining different segments of circles, so that their meeting shall not be perceived, but form a continuous curve line. All ellipses are ovals, but all ovals are not ellipses; for the term oval may be applied to all egg-shaped figures, those which are broader at one end than the other, as well as those whose ends are equally curved.

To describe an Ellipse.

Fig. 4.



To describe an ellipse of any length and width, and by it to describe a pattern for the sides of a vessel of any flare.

First draw an indefinite line D E perpendicular to the line A B, and from C, the point of intersection, as a centre, describe a circle F G, having the diameter equal to the length of the ellipse; from the same centre C describe a circle H J equal to the width; then describe the end circles L K′ and L K, as much less than the width as the width is less than the length; then draw the lines M N and M N tangent to the circles K′L, H J and K L; from the middle of the line M N at O erect a perpendicular produced until it intersects the indefinite line D E; from the point of intersection P as a centre, describe the arc K′H K, and with the same sweep of the dividers mark the point R on the line D E; from the point R draw the lines R U and R V through the points K′ and K where the arc K′ H K touches the end circles K′L and K L; then place one foot of the dividers on the point R and span them to the point H, and describe the arc Q′H Q, which will be equal in length to the arc K′ H K; from the same centre R describe the arc U W V the width of the pattern; then span the dividers the diameter of the end circle K L; place one foot of the dividers on the line R V, at point Q, and the other at Y as a centre, describe the arc Q T the length of the curve line K G, and with the same sweep of the dividers describe the arc T′Q′ from the centre Y′ on the line R U; then span the dividers from Y′ to U, and from Y′ as a centre, describe the arc U X, and from Y as a centre, describe the arc V X, which completes the description of the pattern.

The more flare you wish the pattern to have, the nearer the centre point R must be to H; and the less flare, the further the centre point R must be from H; in the same proportion as you move the centre R towards, or from H, you must move the centre Y towards, or from Q, or which would be the same as spanning the dividers less, or greater, than the diameter of the end circle K L.

To find the Circumference of an Ellipse.

Rule.—Multiply half the sum of the two diameters by 3·1416, and the product will be the circumference.

Example.—Suppose the longer diameter 6 inches and the shorter diameter 4 inches, then 6 added to 4 equal 10, divided by 2 equal 5, multiplied by 3·1416 equal 15·7080 inches circumference.

To find the Area of an Ellipse.

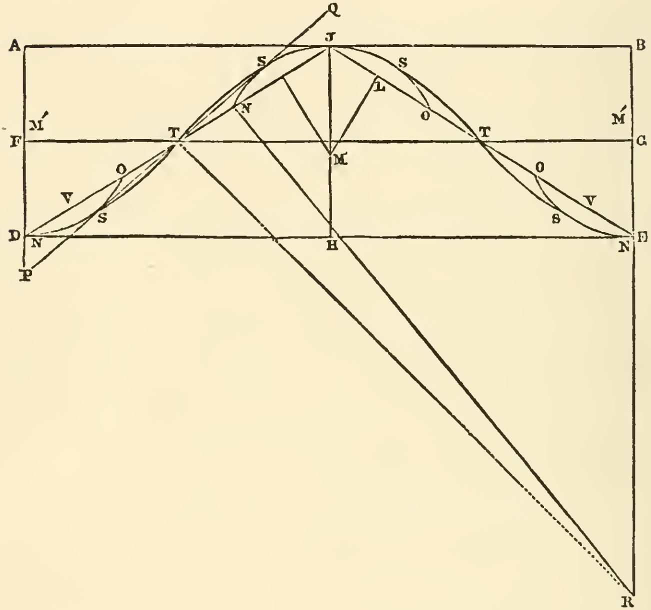
Rule.—Multiply the longer diameter by the shorter diameter, and by ·7854, and the product will be the area.

Example.—Required the area of an ellipse whose longer diameter is 6 inches and shorter diameter 4 inches.

$6 \times 4 \times {\cdot}7854 = 18{\cdot}8496$, the area.

To describe a Right Angled Elbow.

Fig. 5.

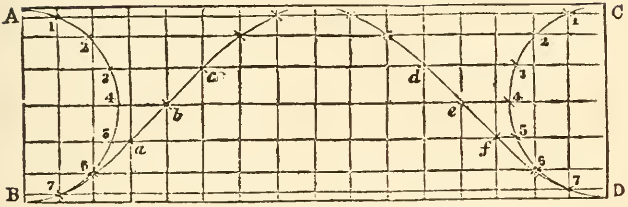


First construct a rectangle A D E B equal in width to the diameter of the elbow, and the length equal to the circumference; then from the point J, the middle of the line A B, draw the line J H, and from the point F, the middle of the line A D, draw the line F G; from the point J draw two diagonal lines J D and J E; then span the dividers so as to divide one of these diagonal lines into six equal parts, viz., J, L, O, T, O, V, E; from the point L erect a perpendicular, produced to the line J H; from the point of contact M, as a centre, describe the arc N J O for the top of the elbow, and from the points M′ and M′ as centres, with the same sweep of the dividers, describe the arcs N O and N O; then draw an indefinite straight line P Q tangent to the arcs N O and N J, having the points of contact at S and S; on this tangent line erect a perpendicular passing through the point N produced until it intersects the line B E produced; then place one foot of the dividers on the point of intersection R and span them over the dotted line to the point T, and with the dividers thus spanned describe the arcs T S, T S, T S, and T S; these arcs and the arcs N O, N J O, and O N will be the right angled elbow required.

To describe a Straight Elbow.

[Old Method.]

Fig. 6.



Mark out the length and depth of the elbow, A B C D; draw a semicircle at each end, as from A B and C D; divide each semicircle into eight parts; draw horizontal lines as shown from 1 to 1, 2 to 2, etc.; divide the circumference or length, A C B D, into sixteen equal parts, and draw perpendicular lines as in figure; draw a line from *a* to *b* and from *b* to *c*, and on the opposite side from *d* to *e* and *e* to *f;* for the top sweep set the dividers on *fourth* line from top and sweep *two* of the spaces; the same at the corner; on space for the remaining sweeps set the dividers so to intersect in the three corners of the spaces marked ×. The seams must be added to drawing.

To describe a Curved Elbow.

Fig. 7.

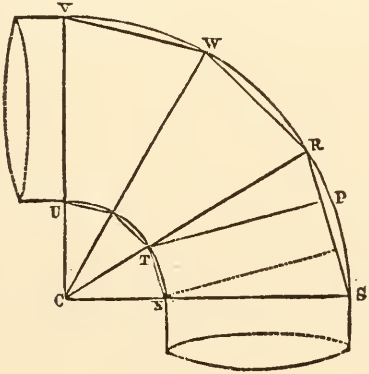
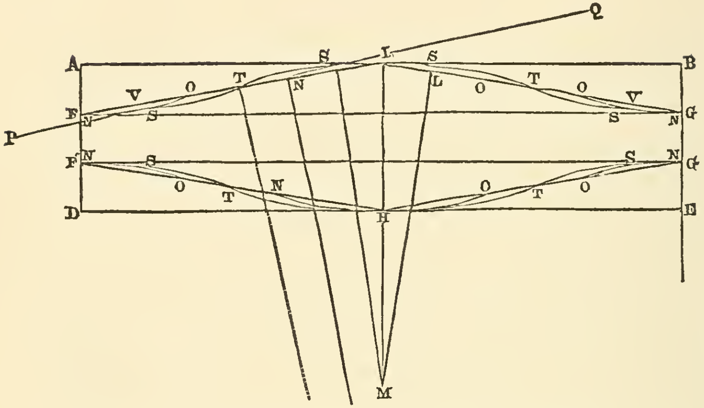


Fig. 8.



Describe two circles U X and V′S, the curves desired for the elbow, having the distance from U to V′ equal to the diameter; then divide the circle V′, W, R and S, into as many sections as desired; then construct a rectangle, *Fig.* 8, A D E B, the width equal to the width of one section V′W, *Fig.* 7, and the length equal to the circumference of the elbow: then span the dividers from the point R to the point P at the dotted line, *Fig.* 7, and with the dividers thus spanned mark the points F F′ *Fig.* 8, from points A and D, and draw the lines F G and F′G′; from point I draw the two diagonal lines I F and I G, span the dividers so as to divide one of these diagonal lines into six equal parts, viz., I, L, O, T, O, V, G; from the point L erect a perpendicular line produced until it intersects the line I H produced; from the point of intersection M, as a centre, describe the arc N I O for the top of the elbow; with the same sweep of the dividers describe the arcs N O and N O; then draw an indefinite straight line P Q tangent to the arcs N O and N I, having the points of contact at S and S; on this tangent line erect a perpendicular line passing through the point N (same as in *Fig.* 5), produced until it intersects the line B E produced; then place one foot of the dividers on the point of intersection and span them over the dotted line to the point T, (same as in *Fig.* 5), and with the dividers spanned describe the arcs T S, T S, T S, and T

S; these arcs and the arcs N O, N I O and O N, will be one side of the section, and by the same rule the other side of the section may be described at the same time, which will be a pattern to cut the other sections by.

To describe a Straight Elbow.

[Another Method for describing a Straight Elbow.]

Figs. 9 and 10.

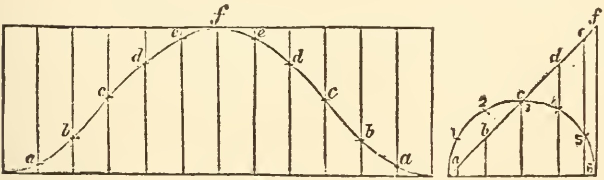


Fig. 10.

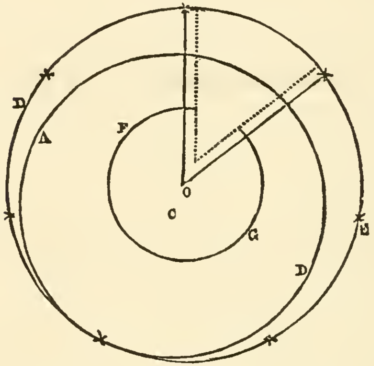
Fig. 9.

Fig. 9.—Draw a profile of half of the elbow wanted, and mark a semicircle on the line representing the diameter, divide the semicircle into six equal parts, draw perpendicular lines from each division on the circle to the angle line as on figure.

Fig. 10.—Draw the circumference and depth of elbow wanted, and divide into twelve equal parts; mark the height of perpendicular lines of *Fig.* 9 on *Fig.* 10 *a b c*, etc.; set your dividers the same as for the semicircle and sweep from *e* to *e* intersecting with *f* and the same from *a* to the *corner*, then set the dividers one-third the circumference and sweep from *e* to *d each side*, and from *a* to *b each side* at bottom; then set your dividers three-fourths of the circumference and sweep from *c* to *d each side* on top, and from *c* to *b* at bottom, and you obtain a more correct pattern than is generally used. Allow for the lap or seam outside of your drawing, and lay out the elbow deep enough to put together by swedge or machine. Be careful in dividing and marking out, and the large end will be true without trimming. The seams must be added to drawing.

To describe Bevel Covers for Vessels, or Breasts for Cans.

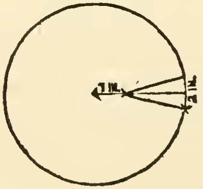
Fig. 11.



From O as a centre, describe a circle D E larger than the vessel; and from C as a centre, describe a circle A B the size of the vessel, then with the dividers the same as you described the circle the size of the vessel, apply them six times on the circumference of the circle larger than the vessel; for can-breasts describe the circle F G the size you wish for the opening of the breast.

To describe Pitched Covers for Pails, etc.

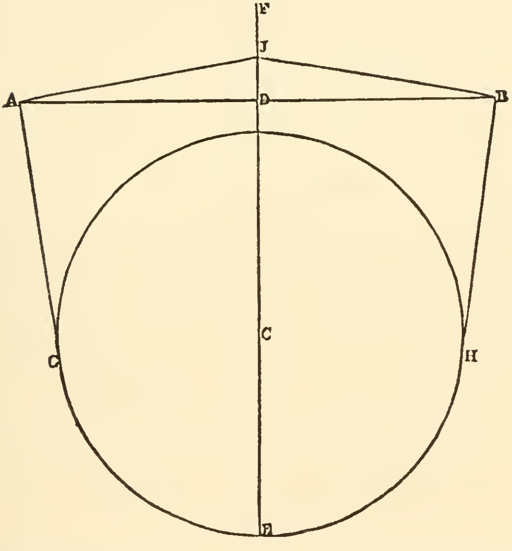
Fig. 12.



To cut for pitched covers, draw a circle one inch larger than the hoop is in diameter after burring, then draw a line from the centre to the circumference as in the figure, and one inch from the centre and connecting with this line draw two more lines, the ends of which shall be one inch on either side of the line first drawn, and then cut out the piece.

To describe an Oval Boiler Cover.

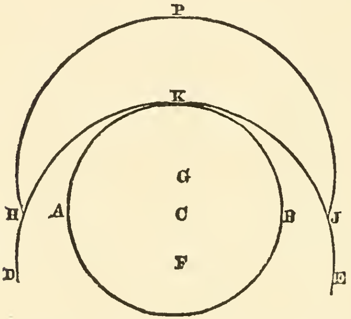
Fig. 13.



From C as a centre, describe a circle whose diameter will be equal to the width of the boiler outside of the wire, and draw the line A B perpendicular to the line E F, having it pass through the point D, which is one-half of the length of the boiler; then mark the point J one quarter of an inch or more as you wish, for the pitch of the cover, and apply the corner of the square on the line A B, allowing the blade to fall on the circle at H, and the tongue at the point J; then draw the lines H B, B J, G A and A J, which completes the description.

To describe a Lip to a Measure.

Fig. 14.



Let the circle A B represent the size of the measure; span the dividers from K to F three-quarters of the diameter; describe the semicircle D K E; move the dividers to G the width of the lip required, and describe the semicircle K P J, which will be the lip sought.

The Circle and its Sections.

1. The *Areas of Circles* are to each other as the squares of their diameters; any circle twice the diameter of another contains four times the area of the other.

2. The *Radius* of a circle is a straight line drawn from the centre to the circumference.

3. The *Diameter* of a circle is a straight line drawn through the centre, and terminated both ways at the circumference.

4. A *Chord* is a straight line joining any two points of the circumference.

5. An *Arc* is any part of the circumference.

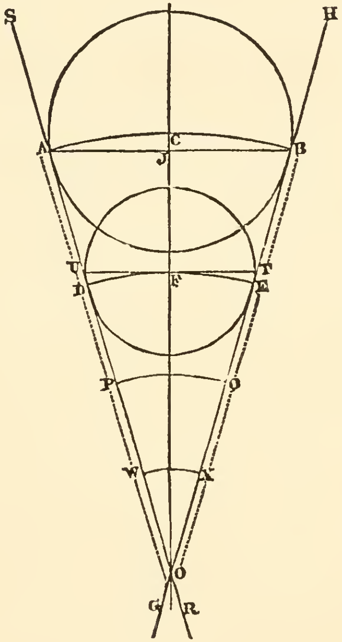
6. A *Semicircle* is half the circumference cut off by a diameter.

7. A *Segment* is any portion of a circle cut off by a chord.

8. A *Sector* is a part of a circle cut off by two radii.

To describe a Flaring Vessel Pattern, a Set of Patterns for a Pyramid Cake, or an Envelope for a Cone.

Fig. 15.

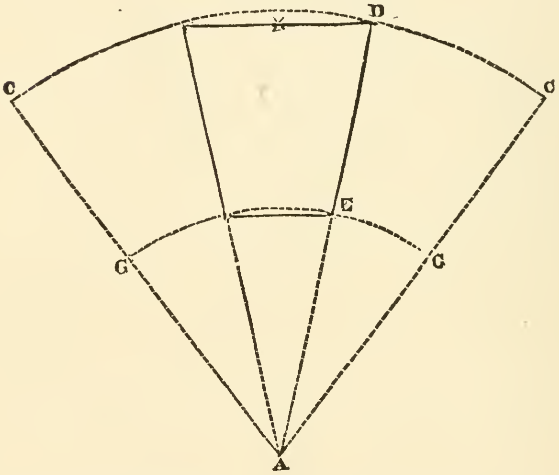


From a point C as a centre, describe a circle A B equal to the large circumference; with the point F as a centre, the depth of the vessel, describe a circle D E equal to the small circumference; then draw the lines G H and R S tangent to the circles A B and D E; from the point of intersection O as a centre, describe the arcs A C B and D F E; then A D E B will be the size of the vessel, and three such pieces will be an envelope for it, and A J B T F U the altitude: then by dividing the sector S O H into sections A B, D E, P Q, and W X, you will have a set of patterns for a pyramid cake; and the sector A O B will be one-third of an envelope for a cone.

In allowing for locks, you must draw the lines parallel to the radii, as represented in the diagram by dotted lines, which will bring the vessel true across the top and bottom.

To describe a Cone or Frustum.

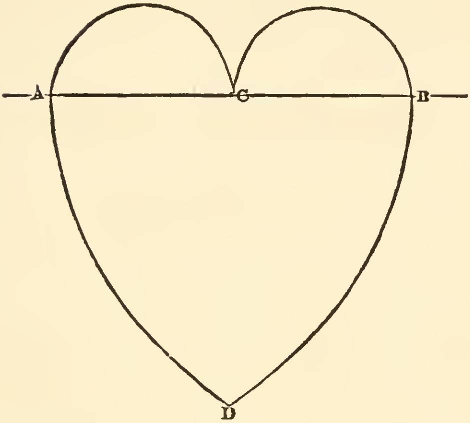
Fig. 16.



First draw a side elevation of the desired vessel, D E, then from A as a centre describe the arcs C D C and G E G; after finding the diameter of the top or large end, turn to the table of Diameters and Circumferences, where you will find the true circumference, which you will proceed to lay out on the upper or larger arc C D C, making due allowance for the locks, wire, and burr. This is for one piece; if for two pieces, you will lay out only one-half the circumference on the plate; if for three pieces, one-third; if for four pieces, one-fourth; and so on for any number, remembering to make the allowance for locks, wire, and burr on the piece you use for a pattern.

To describe a Heart.

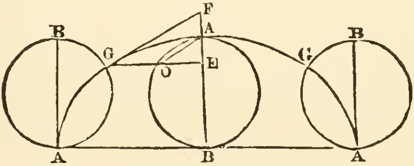
Fig. 17.



Draw an indefinite line A B; then span the dividers one-fourth the width you wish the heart, and describe two semicircumferences A C and C B; span the dividers from A to B, the width of the heart, and describe the lines A D and B D, which completes the description.

Cycloid.

Fig. 18.



Cycloid, a curve much used in mechanics. It is thus formed: If the circumference of a circle be rolled on a right line, beginning at any point A, and continued till the same point A arrives at the line again, making just one revolution, and thereby measuring out a straight line A B A equal to the circumference of a circle, while the point A in the circumference traces out a curve line A C A G A: then this curve is called a cycloid; and some of its properties are contained in the following lemma.

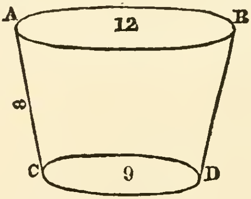
If the generating or revolving circle be placed in the middle of the cycloid, its diameter coinciding with the axis A B, and from any point there be drawn the tangent C F, the ordinate C D E perpendicular to the axis, and the chord of the circle A D; then the chief properties are these:

The right line C D equal to the circular arc A D;
The cycloidal arc A C equal to double the chord A D;
The semi-cycloid A C A equal to double the diameter A B, and
The tangent C F is parallel to the chord A D.

This curve is the line of swiftest descent, and that best suited for the path of the ball of a pendulum.

To Strike the Side of a Flaring Vessel.

Fig. 19.



To find the radius of a circle for striking the side of a flaring vessel having the diameters and depth of side given.

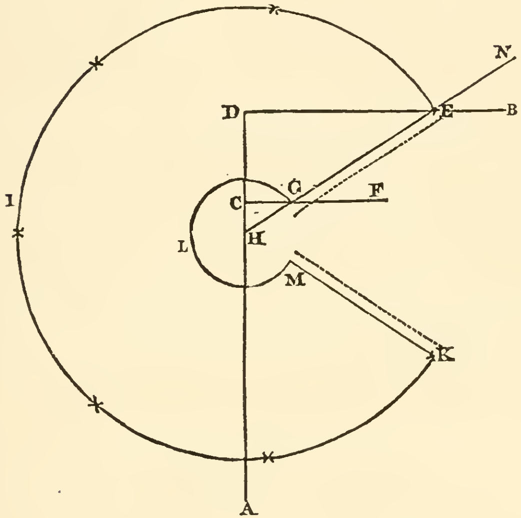
RULE. — As the difference between the large and small diameter is to the depth of the side, so is the small diameter to the radius of the circle by which it is struck.

Example. — Suppose A B C D to be the desired vessel, with a top diameter of 12 inches, bottom diameter 9 inches, depth of side 8 inches. Then as 12 — 9 = 3 : 8 : : 9 to the radius.

8 × 9 = 72 ÷ 3 = 24 *inches, answer.*

To describe Bevel Covers for Vessels, or Breasts for Cans.

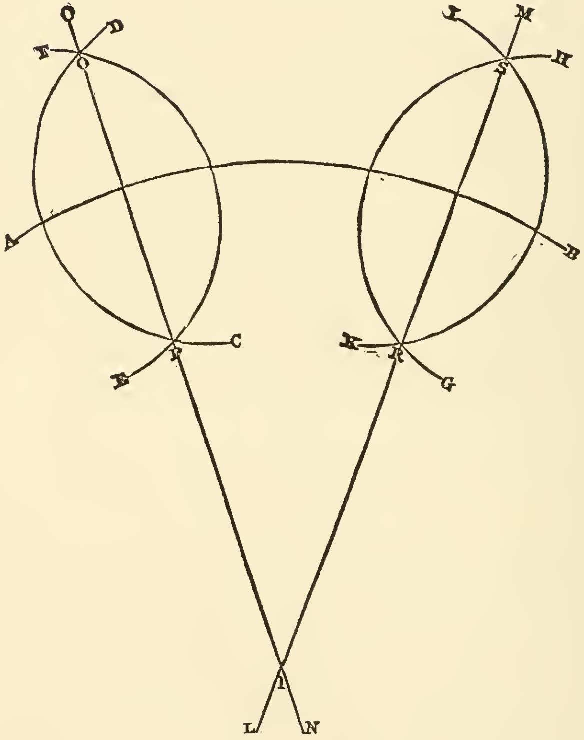
Fig. 20.



Construct a right angle A D B, and from the point C, the altitude height you wish the breast, erect a perpendicular line F; then on the line B, mark the point E one-half the diameter of the can; and on the line F, mark the point G one-half the diameter of the opening in the top of breast; draw a line N to pass through the points E and G produced until it intersects the line A; place one foot of the dividers at the point of intersection H, and place the other on the point E, and describe the circle E I K; span the dividers from the point H to point G, and describe the circle G L M; then span the dividers from the point D to E, and step them six times on the circle E I K, which gives the size of the breast. Remember to mark the lines for the locks parallel with the radii.

To Find the Centre of a Circle from a Part of the Circumference.

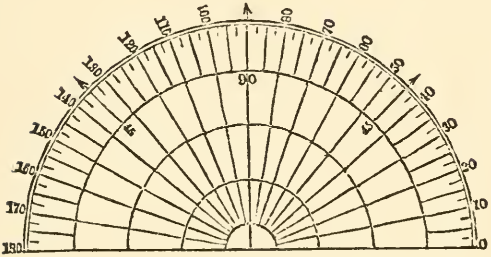
Fig. 21.



Span the dividers any distance you wish, and place one foot on the circumference A B, and describe the semicircumferences C D, E F, G H, and I K, and through the points of their intersection P Q and R S, draw two indefinite lines L M and N O; the point of their intersection T, will be the centre desired.

Sector, for Obtaining Angles.

Fig. 22.



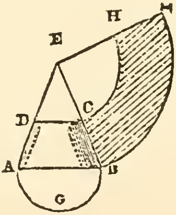
Sector, a portion of a circle comprehended between any two radii and their intercepted arcs. — *Similar Sectors* are those whose radii include equal angles.

To find the area of a sector. Say as 360° is to the degree, etc., in the arc of the sector, so is the area of the whole circle to the area of the sector. Or multiply the radius by the length of the arc, and half the product will be the area.

To Construct the Frustum of a Cone.

Form of flat Plate by which to construct any Frustum of a Cone.

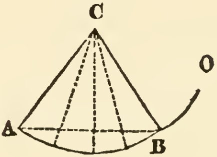
Fig. 23.



Let A B C D represent the required frustum; continue the lines A D and B C until they meet at E; then from E as centre, with the radius E C, describe the arc C H; also from E, with the radius E B, describe the arc B I; make B I equal in length to twice A G B; draw the line E I, and B C I H is the form of the plate as required.

Rule for Striking out a Cone or Frustum.

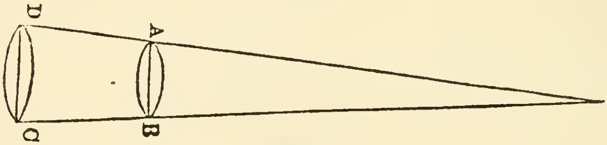
Fig. 24.



In a conical surface, there may be economy, sometimes, in having the slant height 6 times the radius of base. For a Circle may be wholly cut into conical surfaces, if the angle is 60°, 30°, 15°, etc.

But there is a greater simplicity in cutting it, when the angle is 60°. For instance, take A C equal to the slant height, describe an indefinite arc A O; with the same opening of the dividers measure from A to B; draw B C and we have the required sector. This would make the angle C equal 60°. This angle may be divided into two or four equal parts, and we should thus have sectors whose angle would be 30° or 15°, which would not make the vessel very flaring. The accompanying figure gives about the shape of the flaring vessel when the angle of the sector is 30°.

Fig. 25.



To find the Contents of a Pyramid or Cone.

Rule.—Multiply the area of the base by the height, and one-third of the product will be the solid content.

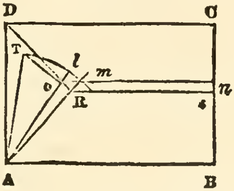
Example.—Required the solid content in inches of a Cone or Pyramid, the diameter of the base being 8 inches, and perpendicular height 18 inches?

$8 \times 8 = 64 \times {\cdot}7854 \times 18 = 904{\cdot}7808 \div 3 = 301{\cdot}5936$ inches $\div 231 = 1$ gall. $1\frac{1}{4}$ qts.

Hipped Roofs, Mill Hoppers, etc.

To find the various Angles and proper Dimensions of Materials whereby to construct any figure whose form is the Frustum of a proper or inverted Pyramid, as Hipped Roofs, Mill Hoppers, etc.

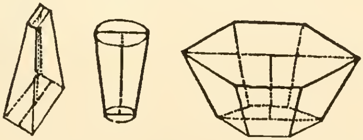
Fig. 26.



Let A B C D be the given dimensions of plan for a roof, the height R T also being given; draw the diagonal A R, meeting the top or ridge R *s* on plan; from R, at right angles with A R and equal to the required height, draw the line R T, then T A, equal the length of the struts or corners of the roof; from A, with the distance A T, describe an arc T *l*, continue the diagonal A R until it cuts the arc T *l*, through which, and parallel with the ridge R *s*, draw the line *m n*, which determines the required breadth for each side of the roof: from A, meeting the line *m n*, draw the line A *o*, or proper angle for the end of each board by which the roof might require to be covered; and the angle at T is what the boards require to be made in the direction of their thickness, when the corners or angles require to be mitred.

Contents in Gallons of the Frustum of a Cone.

Figs. 27, 28, 29.



To find the Contents in Gallons of a Vessel, whose diameter is larger at one end than the other, such as a Bowl, Pail, Firkin, Tub, Coffee-pot, etc.

Rule.— Multiply the larger diameter by the smaller, and to the product add one-third of the square of their difference, multiply by the height, and multiply that product by ·0034 for Wine Gallons, and by ·002785 for Beer.

Example. — Required the contents of a Coffee-pot 6 inches diameter at the top, 9 inches at the bottom, and 18 inches high.

Large diameter 9
Small do. 6
54
⅓ of the square 3
57
Height 18
456
57
Carried up 1026

Brought up 1026
·0034
4104
3078
3·4884 wine gallons,
or nearly 3½ gallons.

1026 multiplied by ·002785 equal 2·8574 *Beer Gallons.*

Rule to find the Contents in Gallons of any Square Vessel.

Rule.— Take the dimensions in inches and decimal parts of an inch, multiply the length, breadth, and height together, and then multiply the product by ·004329 for Wine Gallons, and by ·003546 for Ale Gallons.

Example.— How many Wine Gallons will a box contain that is 10 feet long, 5 feet wide, and 4 feet deep?

Length in inches, 120
Breadth in do. 60
7200
Height in inches, 48
57600
28800
Carried up, 345600

Brought up 345600
·004329
3110400
691200
1036800
1382400
1496·102400 gallons,
or 1496 galls. and 3¼ gills.

Contents in Gallons of Cylindrical Vessels.

Rule.—Take the dimensions, in inches and decimal parts of an inch. Square the diameter, multiply it by the length in inches, and then multiply the product by ·0034 for Wine Gallons, or by ·002785 for Ale Gallons.

Example.—How many U. S. Gallons will a Cylindrical Vessel contain, whose diameter is 9 inches, and length 9½ inches?

Diameter, 9
9
Square Diam. 81
Length, 9·5
405
729
Carried up, 769·5

Brought up 769·5
·0034
30780
23085
2·61630
or 2 gallons and 5 pints.

To Ascertain the Weights of Pipes of various Metals, and any Diameter required.

Thickness in parts of an inch.	Wrought iron.	Copper.			Lead.		
$\frac{1}{32}$	·326	11½	lbs. plate	·38	2	lbs. lead	·483
$\frac{1}{16}$	·653	23½	"	·76	4	"	·967
$\frac{3}{32}$	·976	35	"	1·14	5½	"	1·45
$\frac{1}{8}$	1·3	46½	"	1·52	8	"	1·933
$\frac{5}{32}$	1·627	58	"	1.9	9¼	"	2·417
$\frac{3}{16}$	1·95	70	"	2·28	11	"	2·9
$\frac{7}{32}$	2·277	80½	"	2·66	13	"	3·383
$\frac{1}{4}$	2·6	93	"	3·04	15	"	3.867

Rule.—To the interior diameter of the pipe, in inches, add the thickness of the metal; multiply the sum by the decimal numbers opposite the required thickness and under the metal's name; also by the length of the pipe in feet, and the product is the weight of the pipe in lbs.

1. Required the weight of a copper pipe whose interior diameter is 7½ inches, its length 6¼ feet, and the metal ⅛ of an inch in thickness.

$$7{\cdot}5 \times {\cdot}125 = 7{\cdot}625 \times 1{\cdot}52 \times 6{\cdot}25 = 72{\cdot}4 \text{ lbs.}$$

2. What is the weight of a leaden pipe 18½ feet in length, 3 inches interior diameter, and the metal ¼ of an inch in thickness?

$$3 + {\cdot}25 = 3{\cdot}25 \times 3{\cdot}867 \times 18{\cdot}5 = 232{\cdot}5 \text{ lbs.}$$

Tin Plates.

Size, Length, Breadth, and Weight.

BRAND MARK.	No. of Sheets in Box.	Length and Breadth.	Weight per Box.			
		Inches.	Cwt.	qr.	lbs.	
1 C	225	14 by 10	1	0	0	Each 1 x advances $1.75 to $2.00.
1 x	225	14 by 10	1	1	0	
1 xx	225	14 by 10	1	1	21	
1 xxx	225	14 by 10	1	2	14	
1 xxxx	225	14 by 10	1	3	7	
1 xxxxx	225	14 by 10	2	0	0	
1 xxxxxx	225	14 by 10	2	0	21	
D C	100	17 by 12½	0	3	14	In addition, a great variety of sizes are imported for special purposes, usually costing a little more in proportion than those which are esteemed regular sizes.
D x	100	17 by 12½	1	0	14	
D xx	100	17 by 12½	1	1	7	
D xxx	100	17 by 12½	1	2	0	
D xxxx	100	17 by 12½	1	2	21	
D xxxxx	100	17 by 12½	1	3	14	
D xxxxxx	100	17 by 12½	2	0	7	
S D C	200	15 by 11	1	1	27	
S D x	200	15 by 11	1	2	20	
S D xx	200	15 by 11	1	3	13	
S D xxx	200	15 by 11	2	0	6	
S D xxxx	200	15 by 11	2	0	27	
S D xxxxx	200	15 by 11	2	1	20	
S D xxxxxx	200	15 by 11	2	2	13	
TTT Taggers,	225	14 by 10	about 1	0	0	
1 C	225	12 by 12				About the same weight per Box, as the plates above of similar brand, 14 by 10.
1 x	225	12 by 12				
1 xx	225	12 by 12				
1 xxx	225	12 by 12				
1 xxxx	225	12 by 12				
1 C	112	14 by 20				
1 x	112	14 by 20				
1 xx	112	14 by 20				
1 xxx	112	14 by 20				
1 xxxx	112	14 by 20				
Leaded or Ternes 1 C	112	14 by 20	1	0	0	*For Roofing.*
1 x	112	14 by 20	1	1	0	

Oil Canisters, (*from* 2½ *to* 125 *galls.*,) with the Quantity and Quality of Tin Required for Custom Work.

Galls.	Quantity and Quality.	Galls.	Quantity and Quality.
2½	2 Plates, I X in body.	33	13½ Plates, IX in body, 3
3½	2 " S DX "		breadths high.
5½	2 " DX "	45	13½ Plates, S D X in body.
8	4 " IX "	60	13½ " D X "
10	3½ " DX "	90	15¼ " D X " *
15	4 " DX "	125	20 " D X "

* The bottom tier of plates to be placed lengthwise.

Weight of Water.

1 cubic inch .... is equal to ·03617 pounds.
12 cubic inches .... is equal to ·434 pounds.
1 cubic foot.............. is equal to 62·5 pounds.
1 cubic foot.............. is equal to 7·50 U. S. gallons.
1·8 cubic feet.............. is equal to 112·00 pounds.
35·84 cubic feet.............. is equal to 2240·00 pounds.
1 Cylindrical inch ..... is equal to ·02842 pounds.
12 Cylindrical inches... is equal to ·341 pounds.
1 Cylindrical foot...... is equal to 49·10 pounds.
1 Cylindrical foot...... is equal to 6·00 U. S. gallons.
2·282 Cylindrical feet...... is equal to 112·00 pounds.
45·64 Cylindrical feet...... is equal to 2240·00 pounds.
11·2 Imperial gallons..... is equal to 112·00 pounds.
224 Imperial gallons..... is equal to 2240·00 pounds.
13·44 United States galls. is equal to 112·00 pounds.
268·8 United States galls. is equal to 2240·00 pounds.

Centre of pressure is at two-thirds depth from surface.

Decimal Equivalents to the Fractional Parts of a Gallon, or an Inch.

[*The Inch, or Gallon, being divided into* 32 *parts.*]

[In multiplying decimals it is usual to drop all but the first two or three figures.]

Decimals.	Gallon, or Inch.	Gills.	Pints.	Quarts.	Decimals.	Gallon, or Inch.	Gills.	Pints.	Quarts.	Decimals.	Gallon, or Inch.	Gills.	Pints.	Quarts.
·03125	1-32	1	¼	⅛	·375	3-8	12	3	1½	·71875	23-32	23	5¾	2⅞
·0625	1-16	2	½	¼	·40625	13-32	13	3¼	1⅝	·75	3-4	24	6	3
·09375	3-32	3	¾	⅜	·4375	7-16	14	3½	1¾	·78125	25-32	25	6¼	3⅛
·125	1-8	4	1	½	·46875	15-32	15	3¾	1⅞	·8125	13-16	26	6½	3¼
·15625	5-32	5	1¼	⅝	·5	1-2	16	4	2	·84375	27-32	27	6¾	3⅜
·1875	3-16	6	1½	¾	·53125	17-32	17	4¼	2⅛	·875	7-8	28	7	3½
·21875	7-32	7	1¾	⅞	·5625	9-16	18	4½	2¼	·90625	29-32	29	7¼	3⅝
·25	1-4	8	2	1	·59375	19-32	19	4¾	2⅜	·9375	15-16	30	7½	3¾
·28125	9-32	9	2¼	1⅛	·625	5-8	20	5	2½	·96875	31-32	31	7¾	3⅞
·3125	5-16	10	2½	1¼	·65625	21-32	21	5¼	2⅝	1·000	1	32	8	4
·34375	11-32	11	2¾	1⅜	·6875	11-16	22	5½	2¾					

Application. — Required the *gallons* in any Cylindrical Vessel. Suppose a vessel 9½ inches deep, 9 inches diameter, and contents 2·6163, that is, 2 gallons and 61 hundredth parts of a gallon; now to ascertain this decimal of a gallon, refer to the above Table for the decimal that is nearest, which is ·625, opposite to which is ⅝ths of a gallon, or 20 gills, or 5 pints, or 2½ quarts, consequently the vessel contains 2 gallons and 5 pints.

Inches. — To find what part of an inch the decimal ·708 is. Refer to the above Table for the decimal that is nearest, which is ·71875, opposite to which is 23-32, or nearly ¾ths of an inch.

A TABLE CONTAINING THE DIAMETERS, CIRCUMFERENCES, AND AREAS OF CIRCLES, AND THE CONTENT OF EACH IN GALLONS AT ONE FOOT IN DEPTH.

UTILITY OF THE TABLE.

EXAMPLES.

1. Required the circumference of a circle, the diameter being *five* inches?

In the column of circumferences, opposite the given diameter, stands 15·708* inches, the circumference required.

2. Required the capacity, in gallons, of a can, the diameter being 6 feet and depth 10 feet?

In the fourth column from the given diameter stands 211·4472,* being the content of a can 6 feet in diameter and 1 foot in depth, which being multiplied by 10 gives the required content, two thousand one hundred fourteen and a half gallons.

3. Any of the areas in feet multiplied by ·03704, the product equal the number of cubic yards at 1 foot in depth.

4. The area of a circle in inches multiplied by the length or thickness in inches, and by ·263, the product equal the weight in pounds of cast iron.

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* See preceding page for Decimal Equivalents to the Fractional parts of a Gallon and an Inch.

Diameters and Circumferences of Circles, and the Content in Gallons at 1 Foot in Depth.

[*Area in Inches.*]

Diam.	Circ. in.	Area in.	Gallons.	Diam.	Circ. in.	Area in.	Gallons.
1 in.	3·1416	·7854	·04084	6½	20·420	33·183	1·72552
⅛	3·5343	·9940	·05169	⅝	20·813	34·471	1·79249
¼	3·9270	1·2271	·06380	¾	21·205	35·784	1·86077
⅜	4·3197	1·4848	·07717	⅞	21·598	37·122	1·93034
½	4·7124	1·7671	·09188	7 in.	21·991	38·484	2·00117
⅝	5·1051	2·0739	·10784	⅛	22·383	39·871	2·07329
¾	5·4978	2·4052	·12506	¼	22·776	41·282	2·14666
⅞	5·8905	2·7611	·14357	⅜	23.169	42·718	2·22134
2 in.	6·2832	3·1416	·16333	½	23·562	44·178	2·29726
⅛	6·6759	3·5465	·18439	⅝	23·954	45·663	2·37448
¼	7·0686	3·9760	·20675	¾	24·347	47·173	2·45299
⅜	7·4613	4·4302	·23036	⅞	24·740	48·707	2·53276
½	7·8540	4·9087	·25522	8 in.	25·132	50·265	2·61378
⅝	8·2467	5·4119	·28142	⅛	25·515	51·848	2·69609
¾	8·6394	5·9395	·30883	¼	25·918	53·456	2·77971
⅞	9·0321	6·4918	·33753	⅜	26·310	55·088	2·86458
3 in.	9·4248	7·0686	·36754	½	26·703	56·745	2·95074
⅛	9·8175	7·6699	·39879	⅝	27·096	58·426	3·03815
¼	10·210	8·2957	·43134	¾	27·489	60·132	3·12686
⅜	10·602	8·9462	·46519	⅞	27·881	61·862	3·21682
½	10·995	9·6211	·50029	9 in.	28·274	63·617	3·30808
⅝	11·388	10·320	·53664	⅛	28·667	65·396	3·40059
¾	11·781	11·044	·57429	¼	29·059	67·200	3·49440
⅞	12·173	11·793	·61324	⅜	29·452	69·029	3·58951
4 in.	12·566	12·566	·65343	½	29·845	70·882	3·68586
⅛	12·959	13·364	·69493	⅝	30·237	72·759	3·78347
¼	13·351	14·186	·73767	¾	30·630	74·662	3·88242
⅜	13·744	15·033	·78172	⅞	31·023	76·588	3·98258
½	14·137	15·904	·82701	10 in.	31·416	78·540	4·08408
⅝	14·529	16·800	·87360	⅛	31·808	80·515	4·18678
¾	14·922	17·720	·92144	¼	32·201	82·516	4·29083
⅞	15·315	18·665	·97058	⅜	32·594	84·540	4·39608
5 in.	15·708	19·635	1·02102	½	32·986	86·590	4·50268
⅛	16·100	20·629	1.07271	⅝	33·379	88·664	4·61053
¼	16·493	21·647	1·12564	¾	33·772	90·762	4·71962
⅜	16·886	22·690	1·17988	⅞	34·164	92·885	4·82846
½	17·278	23·758	1·23542	11 in.	34·557	95·033	4·94172
⅝	17·671	24·850	1·29220	⅛	34·950	97·205	5·05466
¾	18·064	25·967	1·35028	¼	35·343	99·402	5·16890
⅞	18·457	27·108	1·40962	⅜	35·735	101·623	5·28439
6 in.	18·849	28·274	1·47025	½	36·128	103·869	5·40119
⅛	19·242	29·464	1·53213	⅝	36.521	106·139	5·51923
¼	19·635	30·679	1·59531	¾	36·913	108·434	5·63857
⅜	20·027	31·919	1·65979	⅞	37·306	110·753	5·75916

Diameters and Circumferences of Circles, and the Content in Gallons at 1 Foot in Depth.—(*Continued.*)

[*Area in Feet.*]

Diam.		Circ.		Area in ft.	Gallons.	Diam.		Circ.		Area in ft.	Gallons.
Ft.	In.	Ft.	In.		1 ft. depth.	Ft.	In.	Ft.	In.		1 ft. depth.
1		3	$1\frac{5}{8}$	·7854	5·8735	4	6	14	$1\frac{5}{8}$	15·9043	118·9386
1	1	3	$4\frac{5}{8}$	·9217	6·8928	4	7	14	$4\frac{5}{8}$	16·4986	123·3830
1	2	3	8	1·0690	7·9944	4	8	14	$7\frac{7}{8}$	17·1041	127·9112
1	3	3	11	1·2271	9·1766	4	9	14	11	17·7205	132·5209
1	4	4	$2\frac{1}{8}$	1·3962	10·4413	4	10	15	$2\frac{1}{8}$	18·3476	137·2105
1	5	4	$5\frac{3}{8}$	1·5761	11·7866	4	11	15	$5\frac{1}{4}$	18·9858	142·0582
1	6	4	$8\frac{1}{2}$	1·7671	13·2150						
1	7	4	$11\frac{5}{8}$	1·9689	14·7241	5		15	$8\frac{1}{2}$	19·6350	146·8384
1	8	5	$2\frac{3}{4}$	2·1816	16·3148	5	1	15	$11\frac{5}{8}$	20·2947	151·7718
1	9	5	$5\frac{7}{8}$	2·4052	17·9870	5	2	16	$2\frac{3}{4}$	20·9656	156·7891
1	10	5	9	2·6398	19·7414	5	3	16	$5\frac{3}{4}$	21·6475	161·8886
1	11	6	$2\frac{1}{4}$	2·8852	21·4830	5	4	16	9	22·3400	167·0674
						5	5	17	$0\frac{1}{8}$	23·0437	172·3300
2		6	$3\frac{3}{8}$	3·1416	23·4940	5	6	17	$3\frac{1}{4}$	23·7583	177·6740
2	1	6	$6\frac{1}{2}$	3·4087	25·4916	5	7	17	$6\frac{3}{8}$	24·4835	183·0973
2	2	6	$9\frac{5}{8}$	3·6869	27·5720	5	8	17	$9\frac{5}{8}$	25·2199	188·6045
2	3	7	$0\frac{3}{4}$	3·9760	29·7340	5	9	18	$0\frac{3}{4}$	25·9672	194·1930
2	4	7	$3\frac{7}{8}$	4·2760	32·6976	5	10	18	$3\frac{7}{8}$	26·7251	199·8610
2	5	7	7	4·5869	34·3027	5	11	18	$7\frac{1}{8}$	27·4943	205·6133
2	6	7	$10\frac{1}{4}$	4·9087	36·7092						
2	7	8	$1\frac{3}{8}$	5·2413	39·1964	6		18	$10\frac{1}{8}$	28.2744	211·4472
2	8	8	$4\frac{1}{2}$	5·5850	41·7668	6	3	19	$7\frac{1}{2}$	30·6796	229·4342
2	9	8	$7\frac{5}{8}$	5·9395	44·4179	6	6	20	$4\frac{7}{8}$	33·1831	248·1564
2	10	8	$10\frac{3}{4}$	6·3049	47·1505	6	9	21	$2\frac{3}{8}$	35·7847	267·6122
2	11	9	$1\frac{7}{8}$	6·6813	49·9654						
						7		21	$11\frac{7}{8}$	38·4846	287·8032
3		9	5	7·0686	52·8618	7	3	22	$9\frac{1}{4}$	41·2825	308·7270
3	1	9	$8\frac{1}{4}$	7·4666	55·8382	7	6	23	$6\frac{3}{4}$	44·1787	330·3859
3	2	9	$11\frac{3}{8}$	7·8757	58·8976	7	9	24	$4\frac{1}{8}$	47·1730	352·7665
3	3	10	$2\frac{1}{2}$	8·2957	62·0386						
3	4	10	$5\frac{5}{8}$	8·7265	65·2602	8		25	$1\frac{1}{2}$	50·2656	375·9062
3	5	10	$8\frac{3}{4}$	9·1683	68·5193	8	3	25	11	53·4562	399·7668
3	6	10	$11\frac{7}{8}$	9·6211	73·1504	8	6	26	$8\frac{3}{8}$	56·7451	424·3625
3	7	11	3	10·0846	75·4166	8	9	27	$5\frac{3}{4}$	60·1321	449·2118
3	8	11	$6\frac{1}{8}$	10·5591	78·9652						
3	9	11	$9\frac{3}{8}$	11·0446	82·5959	9		28	$3\frac{1}{4}$	63·6174	475·7563
3	10	12	$5\frac{1}{2}$	11·5409	86·3074	9	3	29	$0\frac{5}{8}$	67·2007	502·5536
3	11	12	$3\frac{5}{8}$	12·0481	90·1004	9	6	29	$10\frac{1}{8}$	70·8823	530·0861
						9	9	30	$7\frac{1}{2}$	74·6620	558·3522
4		12	$6\frac{3}{4}$	12·5664	93·9754						
4	1	12	$9\frac{7}{8}$	13·0952	97·9310						
4	2	13	1	13·6353	101·9701	10		31	5	78·5400	587·3534
4	3	13	$4\frac{1}{8}$	14·1862	103·0300	10	3	32	$2\frac{3}{8}$	82·5160	617·0876
4	4	13	$7\frac{1}{4}$	14·7479	110·2907	10	6	32	$11\frac{3}{4}$	86·5903	647·5568
4	5	13	$10\frac{1}{2}$	15·3206	114·5735	10	9	33	$9\frac{1}{4}$	90·7627	678·2797

Diam.		Circ.		Area in ft·	Gallons.	Diam.		Circ.		Area in ft.	Gallons.
Ft.	In.	Ft.	In.		1 ft. depth.	Ft.	In.	Ft.	In.		1 ft. depth.
11		34	6⅝	95·0334	710·6977	21		65	11⅝	346·3614	2590·2290
11	3	35	4⅛	99·4021	743·3686	21	3	66	9	354·6571	2652·2532
11	6	36	1½	103·8691	776·7746	21	6	67	6½	363·0511	2715·0413
11	9	36	10⅞	108·4342	810·9143	21	9	68	3⅞	371·5432	2778·5486
12		37	8⅜	113·0976	848·1890	22		69	1⅜	380·1336	2842·7910
12	3	38	5¾	117·8590	881·3966	22	3	69	10¾	388·8220	2907·7664
12	6	39	3¼	122·7187	917·7395	22	6	70	8¼	397·6087	2973·4889
12	9	40	0⅝	127·6765	954·8159	22	9	71	5⅝	406·4935	3039·9209
13		40	10	132·7326	992·6274	23		72	3	415·4766	3107·1001
13	3	41	7½	137·8867	1031·1719	23	3	73	0½	424·5577	3175·0122
13	6	42	4⅞	143·1391	1070·4514	23	6	73	9⅞	433·7371	3243·6595
13	9	43	2¼	148·4896	1108·0645	23	9	74	7¼	443.0146	3313·0403
14		43	11¾	153·9384	1151·2129	24		75	4¾	452·3904	3383.1563
14	3	44	9⅛	159·4852	1192·6940	24	3	76	2⅛	461·8642	3454·0051
14	6	45	6⅝	165·1303	1234·9104	24	6	76	11⅝	471·4363	3525·5929
14	9	46	4	170·8735	1277·8615	24	9	77	9	481·1065	3597.9068
15		47	1½	176·7150	1321·5454	25		78	6⅜	490·8750	3670·9596
15	3	47	10⅞	182·6545	1365·9634	25	3	79	3⅞	500·7415	3744·7452
15	6	48	8¼	188·6923	1407·5165	25	6	80	1¼	510·7063	3819·2657
15	9	49	5¾	194·8282	1457.0032	25	9	80	10¾	520·7692	3894·5203
16		50	3⅛	201·0624	1503·6250	26		81	8⅛	530·9304	3970·5098
16	3	51	0½	207·3946	1550·9797	26	3	82	5¼	541·1896	4047·2322
16	6	51	10	213·8251	1599·0696	26	6	83	3	551·5471	4124·6898
16	9	52	7⅜	220·3537	1647·8930	26	9	84	0⅜	562·0027	4202·9610
17		53	4⅞	226·9806	1697·4516	27		84	9⅞	572·5566	4281·8072
17	3	54	2⅛	233·7055	1747·7431	27	3	85	8⅛	583·2085	4361·4664
17	6	54	11⅝	240·5287	1798·7698	27	6	86	4⅝	593·9587	4441·8607
17	9	55	9⅛	247·4500	1850·5301	27	9	87	2⅛	604·8070	4522·9886
18		56	6½	254·4696	1903·0254	28		87	11½	615·7536	4604·8517
18	3	57	4	261·5872	1956·2537	28	3	88	9	626·7982	4686·4876
18	6	58	1⅜	268·8031	2010·2171	28	6	89	6⅜	637·9411	4770·7787
18	9	58	10¾	276·1171	2064·9140	28	9	90	3¾	649·1821	4854·8434
19		59	8¼	283·5294	2120·3462	29		91	1¼	660·5214	4939·6432
19	3	60	5⅝	291·0397	2176·5113	29	3	91	10⅝	671·9587	5025·1759
19	6	61	3⅛	298·6483	2233·2914	29	6	92	8⅛	683·4943	5111·4487
19	9	62	0½	306·3550	2291·0452	29	9	93	5½	695·1280	5198·4451
20		62	9⅞	314·1600	2349·4141	30		94	2⅞	706·8600	5286·1818
20	3	63	⅜	322·0630	2408·5159	30	3	95	0⅜	718·6900	5374·6512
20	6	64	4¾	330·0643	2468·3528	30	6	95	9¾	730·6183	5463·8558
20	9	65	2¼	338·1637	2528·9233	30	9	96	7¼	742·6447	5553·7940

Capacity of Cans One Inch Deep.

UTILITY OF THE TABLE.

Required the contents of a vessel, diameter 6 7-10*ths* inches, depth 10 inches? By the table a vessel 1 inch deep and 6 and 7-10*ths* inches diameter contains ·15 (hundredths) of a gallon, then ·15 × 10 = 1·50 or 1 gallon and 2 quarts.

Required the contents of a can, diameter 19 8-10*ths* inches, depth 30 inches? By the table a vessel 1 inch deep and 19 and 8-10*ths* inches diameter contains 1 gallon and ·33 (hundredths), then 1·33 × 30 = 39·90 or nearly 40 gallons.

Required the depth of a can whose diameter is 12 and 2-10*ths* inches, to contain 16 gallons.

By the table a vessel 1 inch deep and 12 and 2-10*ths* inches diameter contains ·50 (hundredths) of a gallon, then 16 ÷ ·50 = 32 inches, the depth required, viz.: ·50) 16 (32 × ·50 = 16 gallons.

Diameter.		$\frac{1}{10}$	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$	$\frac{8}{10}$	$\frac{9}{10}$
3	·03	·03	·03	·03	·03	·04	·04	·04	·04	·05
4	·05	·05	·05	·05	·06	·06	·07	·07	·07	·08
5	·08	·08	·08	·09	·09	·10	·10	·11	·11	·11
6	·12	·12	·12	·13	·13	·14	·14	·15	·15	·16
7	·16	·17	·17	·18	·18	·19	·19	·20	·20	·21
8	·21	·22	·22	·23	·23	·24	·25	·25	·26	·26
9	·27	·28	·28	·29	·30	·30	·31	·31	·32	·33
10	·34	·34	·35	·36	·36	·37	·38	·38	·39	·40
11	·41	·41	·42	·43	·44	·44	·45	·46	·47	·48
12	·48	·49	·50	·51	·52	·53	·53	·54	·55	·56
13	·57	·58	·59	·60	·60	·61	·62	·63	·64	·65
14	·66	·67	·68	·69	·70	·71	·72	·73	·74	·75
15	·76	·77	·78	·79	·80	·81	·82	·83	·84	·85
16	·87	·88	·89	·90	·91	·92	·93	·94	·95	·97
17	·98	·99	1·005	1·017	1·028	1·040	1·051	1·063	1·075	1·086
18	1·101	1·113	1·125	1.138	1·150	1·162	1·170	1·187	1·200	1·211
19	1·227	1·240	1·253	1·266	1·279	1·292	1·304	1·317	1·330	1·343
20	1·360	1·373	1·385	1·400	1·414	1·428	1·441	1·455	1·478	1·482
21	1·499	1·513	1·527	1·542	1·556	1·570	1·585	1·600	1·612	1·630
22	1·645	1·660	1·675	1·696	1·705	1·720	1·735	1·750	1·770	1·780
23	1·798	1·814	1·830	1·845	1·861	1·876	1·892	1·908	1·923	1·940
24	1·958	1·974	1·991	2·007	2·023	2·040	2·056	2·072	2·096	2·105
25	2·125	2·142	2·159	2·176	2·193	2·210	2·227	2·244	2·261	2·280
26	2·298	2·316	2·333	2·351	2·369	2·386	2·404	2·422	2·440	2·460
27	2·478	2·496	2·515	2·533	2·552	2·570	2·588	2·607	2·625	2·643
28	2·665	2·684	2·703	2·722	2·741	2·764	2·780	2·800	2·820	2·836
29	2·859	2·879	2·898	2·918	2·938	2·958	2·977	2·997	3·017	3·036
30	3·060	3·080	3·100	3·121	3·141	3·162	3·182	3·202	3·223	3·245
31	3·267	3·288	3·309	3·330	3·351	3·372	3·393	3·414	3·436	3·457
32	3·481	3·503	3·524	3·543	3·568	3·590	3·612	3·633	3·655	3·689
33	3·702	3·725	3·747	3·773	3·795	3·814	3·837	3·860	3·882	3·904
34	3·930	3·953	3·976	4·003	4·022	4·046	4·070	4·092	4·115	4·140
35	4·165	4·188	4·212	4·236	4·260	4·284	4·307	4·331	4·355	4·380
36	4·406	4·430	4·455	4·483	4·503	4·528	4·553	4·577	4·602	4·626
37	4·654	4·679	4·704	4·730	4·755	4·780	4·805	4·834	4·855	4·880
38	4·909	4·935	4·961	4 987	5·012	5·038	5·064	5·090	5·120	5·142
39	5·171	5·197	5·224	5·250	5·277	5·304	5·330	5·357	5·383	5·410
40	5·440	5·467	5·491	5·521	5·548	5·576	5·603	5·630	5·657	5·684

Definition of Arithmetical Signs used in the Work.

$=$ When we wish to state that one quantity or number is equal to another quantity or number, the sign of *equality* $=$ is employed. Thus 3 added to $2 = 5$, or 3 added to 2 is equal to 5.

$+$ When the sum of two quantities or numbers is to be taken, the sign *plus* $+$ is placed between them. Thus $3 + 2 = 5$, that is, the sum of 3 and 2 is 5. This is the sign of Addition.

$-$ When the difference of two numbers or quantities is to be taken, the sign *minus* $-$ is used, and shows that the latter number or quantity is to be taken from the former. Thus $5 - 2 = 3$. This is the sign of Subtraction.

$\times$ When the product of any two numbers or quantities is to be taken, the sign *into* $\times$ is placed between them. Thus $3 \times 2 = 6$. This is the sign of Multiplication.

$\div$ When we are to take the quotient of two quantities, the sign *by* $\div$ is placed between them, and shows that the former is to be divided by the latter. Thus $6 \div 2 = 3$. This is the sign of Division. But in some cases in this work, the mode of division has been to place the dividend above a horizontal line, and the divisor below it, in the form of a vulgar fraction, thus:

$$\frac{\text{Dividend}}{\text{Divisor}} = \text{Quotient.} \qquad \frac{6}{2} = 3.$$

When the square of any number or quantity is to be taken, this is denoted by placing a small figure 2 above it to the right. Thus 6^2 shows that the square of 6 is to be taken, and therefore $6^2 = 6 \times 6 = 36$.

When we wish to show that the square root of any number or quantity is to be taken, this is denoted by placing the *radical sign* $\surd$ before it. Thus $\sqrt{36}$ shows that the square root of 36 ought to be taken, hence $\sqrt{36} = 6$.

The common marks of proportion are also used, viz., : : : : as 3 : 6 : : 4 : 8, being read 3 is to 6 as 4 is to 8.

The application of these signs to the expression of rules is exceedingly simple. Thus, connected with the circle we have the following rules:

1st. The circumference of a circle will be found by multiplying the diameter by 3·1416.

2d. The diameter of a circle may be found by dividing the circumference by 3·1416.

3d. The area of a circle may be found by multiplying the half of the diameter by the half of the circumference, or by multiplying together the diameter and circumference, and dividing the product by 4, or by squaring the diameter, and multiplying by ·7854.

Now all these rules may be thus expressed:

1st. $\text{diameter} \times 3{\cdot}1416 = \text{circumference}.$

2d. $\dfrac{\text{circumference}}{3{\cdot}1416} = \text{diameter}.$

3d. $\dfrac{\text{diameter}}{2} \times \dfrac{\text{circumference}}{2} = \text{area}.$

or, $\dfrac{\text{diameter} \times \text{circumference}}{4} = \text{area}.$

or, $\text{diameter}^2 \times {\cdot}7854 = \text{area}.$

PRACTICAL GEOMETRY.

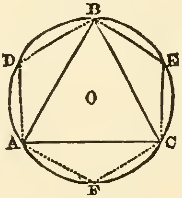
PRACTICAL Geometry is an important branch of knowledge to all who are in any way engaged in the art of building. The workman, as well as the designer, requires its aid; and unless he is acquainted with some of the leading principles of the science, he will frequently feel an uncertainty as to the results he may deduce from the problems which are presented to his notice.

PROBLEM I.

To inscribe an Equilateral Triangle within a given Circle.

Let A B C be a circle; it is required to draw within it a triangle whose sides are equal to one another. Commencing from any point A, mark on the circumference of the circle a series of spaces equal to the radius of the circle, of which there will be six, and draw the arcs A D D B, etc. Then join every alternate point as A B, B C, C A, and the several lines will together form an equilateral triangle.

Fig. 30.

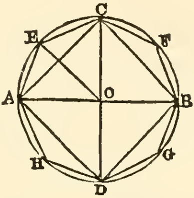


PROBLEM II.

Within a given Circle to inscribe a Square.

Let A B C D be the given circle, it is required to draw a square within it. Draw the diameters A B, C D, at right angles to each other; or, in other words, draw the diameter A B, and form a perpendicular bisecting it. Then join the points A C, C B, B D, D A, and the figure A B C D is a square formed within a given circle.

Fig. 31.

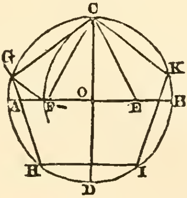


PROBLEM III.

Within a given Circle to inscribe a regular Pentagon; that is, a Polygon of five Sides.

Let A B C D be a circle in which it is required to draw a pentagon. Draw a diameter A D, and perpendicular to it another diameter.

Fig. 32.



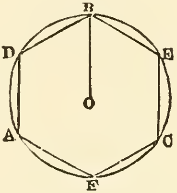
Then divide O B into two equal parts in the point E, and join C E; and with E as a centre, and the radius C E, draw the arc C F, cutting A O in F; and, with C as a centre, and the same radius, describe the arc F G; the arcs C F, G F intersect each other in the point F, and the arc G F intersects the circumference of the circle in the point G. Join the points C and G, and that line will be a side of the pentagon to be drawn. Mark off within the circumference the same space, and join the points A H, H I, I K, K C, and the figure that is formed is a pentagon.

PROBLEM IV.

Within a given Circle to describe a regular Hexagon; that is to say, a Polygon of six equal Sides.

Let A B C be the given circle, and O the centre. With the radius of the circle divide it into parts, of which there will be six, and connect the points A D, D B, etc., and the figure A D B E C F will be a regular hexagon.

Fig. 33.

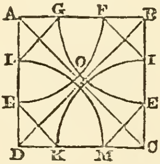


PROBLEM V.

To cut off the Corners of a given Square, so as to form a regular Octagon.

Let A B C D be the given square. Draw the two diagonal lines A C, and B D, crossing each other in O. Then, with the radius A O, that is, half the diagonal, and with A as a centre, describe the arc E F, cutting the sides of the square in E and F; then, from B as a centre, describe the arc G H; and in like manner from C and D describe the arcs I K and L M. Draw the lines L G, F I, H M, and K E, and these, with the parts of the given square G F, I H, M K, and E L, form the octagon required.

Fig. 34.

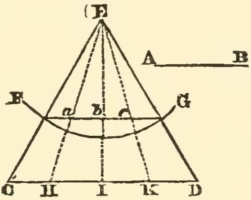


PROBLEM VI.

To divide a given Line into any Number of Parts, which Parts shall be in the same Proportion to each other as the Parts of some other given Line, whether those Parts are equal or unequal.

Let A B be the given line which it is required to divide in the same manner and proportion as the line C D, whether the parts are equal or unequal. On the base line C D, form an equilateral triangle in the manner already described in a former problem. Then take the distance A B, and with E as a centre, describe the arc F G, and join the points F and G, and F G shall be equal to A B. Now,

Fig. 35.



if from the points H I K, which are the divisions of the line C, we draw lines to E, as H E, I E, and K E, these lines will cut F G in the points *a b c*, which will divide the line F G into parts proportionate to the divisions of the line C D.

Problem VII.

On a given Line to draw a Polygon of any Number of Sides, so that that Line shall be one side of a Polygon; or, in other words, to find the Centre of a Circle which shall circumscribe any Polygon, the Length of the Side of the Polygon being given.

We shall here show, in a tabular form, the length of the radius of a circle, which shall contain the given line, as a side of the required polygon; and here we will suppose the line to be divided into one thousand equal parts, and the radius into a certain number of like parts. The radius of the circle for different figures will be as follows:

For an inscribed	Triangle	577
	Square	701
	Pentagon	850
	Hexagon	1000
	Heptagon	1152
	Octagon	1306½
	Enneagon	1462
	Decagon	1618
	Endecagon	1775
	Dodecagon	1932

By this table the workman may, with a simple proportion, find the radius of a circle which shall contain a polygon, one side being given: thus, if it be required to draw a pentagon, the side given being fifteen inches, we may say as 1000 is to 15, so is 850, the tabular number for a pentagon, to 12 inches and seventy-five hundredth parts of an inch, or seven-tenths and a half of a tenth of an inch.

We may here give another table for the construction of polygons, one in which the radius of the circumscribing circle is given. If it be required to find the side of the inscribed polygon, the radius being one thousand parts, the sides of the different polygons will be according to the following scale:

The Triangle	1732
Square	1414
Pentagon	1175
Hexagon	1000
Heptagon	867½
Octagon	765
Enneagon	684
Decagon	618
Endecagon	563½
Dodecagon	517½

Here, as in the case already mentioned, the law of proportion applies, and the statement may be thus made: as one thousand is to the number of inches contained in the radius of the given circle, so is the tabular number for the required polygon to the length of one of its sides in inches. Thus, let it be supposed that we have a circle whose radius in inches is 30, and that we wish to inscribe an octagon within it; then say as 1000 is to 30 inches, so is 765 to 22 inches and 95-100 parts of an inch, the length of the side of the required octagon.

Method of Drawing Curved Lines.

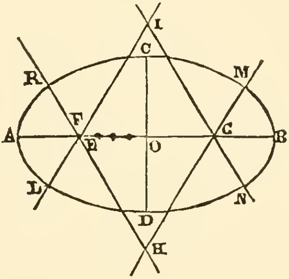
We will now introduce a few remarks upon the method of drawing curved lines, and also give some rules for finding the forms of mouldings when they are to mitre together, that is to say, of raking mouldings, and of bevel work in general. It will also be necessary to make a few remarks upon the form of ribs for domes and groins, a knowledge of which is so necessary to the builder that without it the workman cannot correctly execute his task. It is hardly necessary to state, that all these mechanical operations are founded upon geometrical principles; and, unless he is acquainted with these, the workman cannot hope to succeed in his attempt to excel in his art,—one which is necessary for the comfort and convenience of all communities.

PROBLEM VIII.

To draw an Ellipse with the Rule and Compasses, the transverse and conjugate Diameters being given; that is, the length and width.

Let A B be the transverse or longest diameter; C D the conjugate or shortest diameter; and O the point of their intersection, that is, the centre of the ellipse. Take the distance O C or O D; and, taking A as one point, mark that distance A E upon the line A O. Divide O E into three equal parts, and take from A F, a distance E F, equal to one of those parts. Make O G equal to O F. With the radius F G, and F and G as centres, strike arcs which shall intersect each other in the points I and H. Then draw the lines H F K, H G M, and I F L, I G N. With F as a centre, and the radius A F, describe the arc L A K; and, from G as a centre, with the same radius, describe the arc M B N. With the radius H C, and H as a centre, describe the arc K C M; and, from the point I, with the radius I D, describe the arc L D M. The figure A C B D is an ellipse, formed of four arcs of circles.

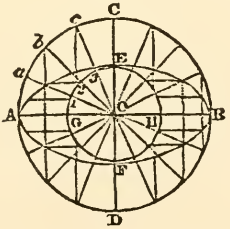
Fig. 36.



PROBLEM IX.

To draw an Ellipse by means of two Concentric Circles.

Fig. 37.



Let A B be the transverse, and E F the conjugate diameter, and O the centre of an ellipse to be drawn. From O with the radius

O A, describe the circle A C B D, and from the same centre describe another circle G E H F. Divide the outer circle into any number of equal parts; the greater the number, the more exact will be the ellipse: and they should not be less than twelve. From each of these divisions draw lines to the centre O, as *a* O, *b* O, *c* O. Then, from *a*, *b*, *c*, etc., draw lines perpendicular to A B, and from the corresponding points in the inner circle, that is, from the points marked 1, 2, 3, etc., draw lines parallel to A B. Draw a curve through the points where these lines intersect each other, and it will be an ellipse.

In the diagram to which this demonstration refers, only one quarter of the ellipse is lettered, but the process described in relation to that must be carried round the circles, as is shown in the dotted and other lines.

PROBLEM X.

To describe an Ellipse by Means of a Carpenter's Square, or a piece of notched Lath.

Having drawn two lines to represent the diameters of the ellipse required, fasten the square so that the internal angle or meeting of the blade and stock shall be at the centre of the ellipse. Then take a piece of wood or a lath, and cut it to the length of half the longest diameter, and from one end cut out a piece equal to half the shortest diameter, and there will then be a piece remaining at one end equal to the difference of the half of the two diameters. Place this projecting piece of the lath in such a manner that it may rest against the square, on the edge which corresponds to the two diameters; then, turning it round horizontally, the two ends of the projection will slide along the two internal edges of the square, and if a pencil be fixed at the other end of the lath, it will describe one quarter of an ellipse. The square must then be moved for the successive quarters of the ellipse, and the whole figure will thus be easily formed.

This method of forming an ellipse is a good substitute for the usual plan, and the figure thus produced is more accurate than that made by passing a pencil round a string moving upon two pins or nails fixed in the foci, for the string is apt to stretch, and the pencil cannot be guided with the accuracy required.

There are many other methods of drawing ellipses, or more properly ovals, but we can only notice two of those in common use.

1. By ordinates, or lines drawn perpendicular to the axis. Having formed the two diameters, divide the axis, or larger diameter, into any number of equal parts, and erect lines perpendicular to the several points. Next draw a semicircle, and divide its diameter into the like number of equal parts; that is, if the larger diameter or axis of the intended ellipse be divided into twenty equal parts, then the semicircle must be divided into the like number. As the diameter of the semicircle is equal to the shorter

diameter of the ellipse, or conjugate axis, perpendiculars may be raised from these divisions of the diameter, or the semicircle, till they meet the circumference; and the different perpendiculars, which are called ordinates, may be erected like perpendiculars, on the axis of ellipse. Joining the several points together, the ellipse is described; and the more accurately the perpendiculars are formed, the more exact will be the ellipse.

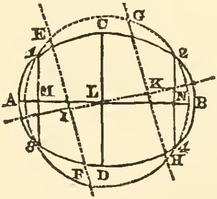
2. By intersecting arches. Take any point in the axis, and with a radius equal to the distance of that point from one extremity of the axis, and with one of the foci as a centre, describe an arc; then with the distance of the assumed point in the axis from the other end of it, and with the other focus as a centre, describe another arc intersecting the former, and the point of intersection will be a point in the ellipse. By assuming any number of points in the axis, any number of points on the curve may be found, and these united will give the ellipse. This process is founded on the property of the ellipse; that if any two lines are drawn from the foci to any point in the curve, the length of these lines added together will be a constant quantity, that is, always the same in the same ellipse.

Problem XI.

To find the Centre and the two Axes of an Ellipse.

Let A B C D be an ellipse, it is required to find its centre. Draw any two lines, as E F and G H, parallel and equal to each other.

Fig. 38.



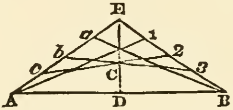
Bisect these lines as in the points I and K, and bisect I K as in L. From L, as a centre, draw a circle cutting the ellipse in four points, 1, 2, 3, 4. Now L is the centre of the ellipse. But join the points 1, 3, and 2, 4; and bisect these lines as in M and N. Draw the line M N, and produce it to A and B, and it will be the transverse axis. Draw C D through L, and perpendicular to A B, and it will be the conjugate or shorter axis.

PROBLEM XII.

To draw a flat Arch by the intersection of Lines, having the Opening and Spring or Rise given.

Let A D B be the opening, and C D its spring or rise. In the middle of A B, at D, erect a perpendicular D E, equal to twice C D, its rise; and from E draw E A and E B, and divide A E and B E into any number or equal parts, as *a*, *b*, *c*, and 1, 2, 3. Join B *a*, 3 *c*, 2 *b*, and 1 A, and it will form the arch required.

Fig. 39.



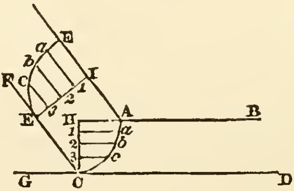
The more parts A E and B E are divided into, the greater will be the accuracy of the curve.

Many curves may be made in the same manner, according to the position of the lines A E and E B; and if instead of two lines drawn from A and B, meeting in E, a perpendicular be erected at the same points, and two lines be then drawn from the ends of these perpendiculars meeting in an angle, and these lines be divided into any number of equal parts, the points of the adjacent lines may be joined, and a curve will be formed resembling a Gothic arch. The demonstration already given is therefore very useful to the workman, as he may vary the form of the curve by altering the position of the lines, either with respect to the angles which they make with each other, or their proportional lengths.

PROBLEM XIII.

To find the Form or Curvature of a Raking Moulding that shall unite correctly with a Level one.

Fig. 40.



Let A B C D be part of the level moulding, which we will here suppose to be an ovolo, or quarter round; A and C, the points where the raking moulding takes its rise on the angle; F C G, the angle the raking moulding makes with the horizontal one. Draw

C F at the given angle, and from A draw A E parallel to it; continue B A to H, and from C make C H perpendicular to A H. Divide C H into any number of equal parts, as 1, 2, 3, and draw lines parallel to H A, as 1 *a*, 2 *b*, 3 *c;* and then in any part of the raking moulding, as I, draw I K perpendicular to E A, and divide I K into the same number of equal parts H C is divided into; and draw 1 *a*, 2 *b*, 3 *c*, parallel to E A. Then transfer the distances 1 *a*, 2 *b*, 3 *c*, and a curve drawn through these points will be the form of the curve required for the raking moulding.

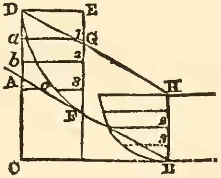
We have here shown the method to be employed for an ovolo; but it is just the same for any other formed moulding, as a cavetto, semirecta, etc. It may be worthy remark, that, after the moulding is worked, and the mitre is cut in the mitre-box for the level moulding, the raking moulding must be cut, either by the means of a wedge formed to the required angle of the rake, or a box made to correspond to that angle: and if this be accurately done, the mitre will be true, and the moulding in all its members correspond to the level moulding. The plane in which the raking moulding is situated is square to that of the level one. This is always the case in a pediment, the mouldings of which correspond with the return.

PROBLEM XIV.

To find the Form or Curvature of the Return in an open or broken Pediment.

Let A B C be the angle which the pediment makes with the cornice, and let the form and size of the moulding be as in the last problem, and as shown at D A B H. From D drop a perpendicular on C B, and draw D E perpendicular to D C, or parallel to C B; and let D E be equal to E I (Fig. 40). Then from E draw E F parallel to D A, and divide E F into the same number of parts as I K (Fig. 40), at 1 *a*, 2 *b*, 3 *c*, and transfer the distances 1 *a*, 2 *b*, 3 *c*, as in Fig. 40. Then a curve line drawn through the points *a*, *b*, *c*, will be the form of the return for the moulding of the open pediment.

Fig. 41.



The mitre for the return is cut in the usual manner, but that of the pediment is cut to the proper angle of its inclination, as in the last problem. In fixing the mitre, the portion E D G of the return must be cut away to make it come flush with the top of the pediment moulding.

EPITOME OF MENSURATION.

Of the Circle, Cylinder, Sphere, etc.

1. The *circle* contains a greater area than any other plane figure bounded by an equal perimeter or outline.

2. The *areas of circles* are to each other as the squares of their diameters.

3. The *diameter of a circle* being 1, its circumference equals 3·1416.

4. The *diameter of a circle* is equal to ·31831 of its circumference.

5. The square of the diameter of a *circle* being 1, its area equals ·7854.

6. The square root of the area of a *circle*, multiplied by 1·12837, equals its diameter.

7. The diameter of a *circle* multiplied by ·8862, or the circumference multiplied by ·2821, equals the side of a square of equal area.

8. The sum of the squares of half the chord and versed sine divided by the versed sine, the quotient equals the diameter of corresponding circle.

9. The chord of the whole *arc of a circle* taken from eight times the chord of half the arc, one-third of the remainder equals the length of the arc; or,

10. The number of degrees contained in the *arc of a circle*, multiplied by the diameter of the circle and by ·008727, the product equals the length of the arc in equal terms of unity.

11. The length of the arc of a *sector of a circle* multiplied by its radius, equals twice the area of the sector.

12. The area of the *segment of a circle* equals the area of the sector, minus the area of a triangle whose vertex is the centre, and whose base equals the chord of the segment; or,

13. The *area of a segment* may be obtained by dividing the height of the segment by the diameter of the circle, and multiplying the corresponding tabular area by the square of the diameter.

14. The sum of the diameters of two *concentric circles* multiplied by their difference and by ·7854, equals the area of the ring or space contained between them.

15. The sum of the thickness and internal diameter of a *cylindric ring*, multiplied by the square of its thickness and by 2·4674, equals its solidity.

16. The circumference of a *cylinder*, multiplied by its length or height, equals its convex surface.

17. The area of the end of a *cylinder*, multiplied by its length, equals its solid contents.

18. The area of the internal diameter of a *cylinder*, multiplied by its depth, equals its cubical capacity.

19. The square of the diameter of a *cylinder*, multiplied by its length and divided by any other required length, the square root of the quotient equals the diameter of the other cylinder of equal contents or capacity.

20. The square of the diameter of a *sphere*, multiplied by 3·1416, equals its convex surface.

21. The cube of the diameter of a *sphere*, multiplied by ·5236, equals its solid contents.

22. The height of any spherical *segment* or *zone*, multiplied by the diameter of the sphere of which it is a part, and by 3·1416, equals the area or convex surface of the segment; or,

23. The height of the *segment*, multiplied by the circumference of the sphere of which it is a part, equals the area.

24. The solidity of any *spherical segment* is equal to three times the square of the radius of its base, plus the square of its height, and multiplied by its height and by ·5236.

25. The solidity of a *spherical zone* equals the sum of the squares of the radii of its two ends, and one-third the square of its height, multiplied by the height and by 1·5708.

26. The capacity of a *cylinder*, 1 foot in diameter and 1 foot in length, equals 5·875 of a United States gallon.

27. The capacity of a *cylinder*, 1 inch in diameter and 1 foot in length, equals ·0408 of a United States gallon.

28. The capacity of a *cylinder*, 1 inch in diameter and 1 inch in length, equals ·0034 of a United States gallon.

29. The capacity of a *sphere*, 1 foot in diameter, equals 3·9156 United States gallons.

30. The capacity of a *sphere*, 1 inch in diameter, equals ·002165 of a United States gallon; hence,

31. The capacity of any other *cylinder* in United States gallons is obtained by multiplying the square of its diameter by its length, or the capacity of any other sphere by the cube of its diameter, and by the number of United States gallons contained as above in the unity of its measurement.

Of the Square, Rectangle, Cube, etc.

1. The side of a *square* equals the square root of its area.

2. The area of a *square* equals the square of one of its sides.

3. The diagonal of a *square* equals the square root of twice the square of its side.

4. The side of a *square* is equal to the square root of half the square of its diagonal.

5. The side of a *square* equal to the diagonal of a given square contains double the area of a given square.

6. The area of a *rectangle* equals its length multiplied by its breadth.

7. The length of a *rectangle* equals the area divided by the breadth; or, the breadth equals the area divided by the length.

8. The side or end of a *rectangle* equals the square root of the sum of the diagonal and opposite side to that required, multiplied by their difference.

9. The diagonal in a *rectangle* equals the square root of the sum of the squares of the base and perpendicular.

10. The solidity of a *cube* equals the area of one of its sides, multiplied by the length or breadth of one of its sides.

11. The length or breadth of a side of a *cube* equals the cube root of its solidity.

12. The capacity of a 12-inch *cube* equals 7·4784 United States gallons.

Surfaces and Solidities of the Regular Bodies, each of whose Boundary Lines is 1.

No. of Sides.	Names.	Surfaces.	Solids.
4	Tetrahedron.	1·7321	0·1179
6	Hexahedron.	6.	1.
8	Octahedron.	3·4641	0·4714
12	Dodecahedron.	20·6458	7·6631
20	Icosahedron.	8·6603	2·1817

The tabular surface multiplied by the square of one of the boundary lines equals the surface required; or,

The tabular solidity multiplied by the cube of one of the boundary lines equals the solidity required.

Of Triangles, Polygons, etc.

1. The complement of an *angle* is its defect from a right angle.

2. The supplement of an *angle* is its defect from two right angles.

3. The sine, tangent, and secant of an *angle* are the cosine, cotangent, and cosecant of the complement of that angle.

4. The hypothenuse of a right-angled *triangle* being made radii, its sides become the sines of the opposite angles, or the cosines of the adjacent angles.

5. The three angles of every *triangle* are equal to two right angles; hence the oblique angles of a right-angled triangle are each others complements.

6. The sum of the squares of the two given sides of a right-angled *triangle* is equal to the square of the hypothenuse.

7. The difference between the squares of the hypothenuse and given side of a right-angled *triangle* is equal to the square of the required side.

8. The area of a *triangle* equals half the product of the base multiplied by the perpendicular height; or,

9. The area of a *triangle* equals half the product of the two sides and the natural sine of the contained angle.

10. The side of any regular *polygon* multiplied by its apothegm or perpendicular, and by the number of its sides, equals twice the area.

Table of the Areas of Regular Polygons, each of whose Sides is Unity.

Name of Polygon.	No. of Sides.	Apothegm or Perpend'lar.	Area when Side is Unity.	Interior Angle.	Central Angle.
Triangle.....	3	0·2887	0·4330	60° 0′	120° 0′
Square........	4	0·5	1·	90 0	90 0
Pentagon.....	5	0·6882	1·7205	108 0	72 0
Hexagon	6	0·8660	2·5981	120 0	60 0
Heptagon....	7	1·0386	3·6339	128 $34\frac{2}{7}$	51 $25\frac{3}{7}$
Octagon......	8	1·2071	4·8284	135 0	45 0
Nonagon.....	9	1·3737	6·1818	140 0	40 0
Decagon......	10	1·5388	7·6942	144 0	36 0
Undecagon..	11	1·7028	9·3656	147 $16\frac{4}{11}$	32 $43\frac{7}{11}$
Dodecagon...	12	1·8660	11·1962	150 0	30 0

The tabular area of the corresponding polygon multiplied by the square of the side of the given polygon equals the area of the given polygon.

Of Ellipses, Cones, Frustums, etc.

1. The square root of half the sum of the squares of the two diameters of an *ellipse* multiplied by 3·1416 equals its circumference.

2. The product of the two axes of an *ellipse* multiplied by ·7854 equals its area.

3. The curve surface of a *cone* is equal to half the product of the circumference of its base multiplied by its slant side, to which, if the area of the base be added, the sum is the whole surface.

4. The solidity of a *cone* equals one-third of the product of its base multiplied by its altitude or height.

5. The squares of the diameters of the two ends of the *frustum of a cone* added to the product of the two diameters, and that sum multiplied by its height and by ·2618, equals its solidity.

INSTRUMENTAL ARITHMETIC,

OR UTILITY OF THE SLIDE RULE.

The slide rule is an instrument by which the greater portion of operations in arithmetic and mensuration may be advantageously performed, provided the lines of division and gauge-points be made properly correct, and their several values familiarly understood.

The lines of division are distinguished by the letters A B C D; A B and C being each divided alike, and containing what is termed a double radius, or double series of logarithmic numbers, each series being supposed to be divided into 1000 equal parts, and distributed along the radius in the following manner:

From 1 to	2	contains	301	of those parts,	being the	log. of	2.
"	3	"	477	"	"	"	3.
"	4	"	602	"	"	"	4.
"	5	"	699	"	"	"	5.
"	6	"	778	"	"	"	6.
"	7	"	845	"	"	"	7.
"	8	"	903	"	"	"	8.
"	9	"	954	"	"	"	9.

1000 being the whole number.

The line D on the improved rules consists of only a single radius; and although of larger radius, the logarithmic series is the same, and disposed of along the line in a similar proportion, forming exactly a line of square roots to the numbers on the lines B C.

Numeration.

Numeration teaches us to estimate or properly value the numbers and divisions on the rule in an arithmetical form.

Their values are all entirely governed by the value set upon the first figure, and being decimally reckoned, advance tenfold from the commencement to the termination of each radius: thus, suppose 1 at the joint be one, the 1 in the middle of the rule is ten, and 1 at the end, one hundred; again, suppose 1 at the joint ten, 1 in the middle is 100, and 1 or 10 at the end is 1000, etc., the intermediate divisions on which complete the whole system of its notation.

To Multiply Numbers by the Rule.

Set 1 on B opposite to the multiplier on A; and against the number to be multiplied on B is the product on A.

Multiply 6 by 4.

Set 1 on B to 4 on A; and against 6 on B is 24 on A.

The slide thus set, against 7 on B is 28 on A.
8 " 32 "
9 " 36 "
10 " 40 "
12 " 48 "
15 " 60 "
25 " 100 " etc.

To Divide Numbers upon the Rule.

Set the divisor on B to 1 on A; and against the number to be divided on B is the quotient on A.

Divide 63 by 3.

Set 3 on B to 1 on A; and against 63 on B is 21 on A.

Proportion, or Rule of Three Direct.

Rule. — Set the first term on B to the second on A; and against the third upon B is the fourth upon A.

1. If 4 yards of cloth cost 38 cents, what will 30 yards cost at the same rate?

Set 4 on B to 38 on A; and against 30 on B is 285 cents on A.

2. Suppose I pay 31 dollars 50 cents for 3 cwt. of copper, at what rate is that per ton? 1 *ton* = 20 *cwt.*

Set 3 upon B to 31.5 upon A; and against 20 upon B is 210 upon A.

Rule of Three Inverse.

Rule. — Invert the slide, and the operation is the same as direct proportion.

1. I know that six men are capable of performing a certain given portion of work in eight days, but I want the same performed in three; how many men must there be employed?

Set 6 upon C to 8 upon A; and against 3 upon C is 16 upon A.

2. The lever of a safety-valve is 20 inches in length, and 5 inches between the fixed end and centre of the valve; what weight must there be placed on the end of the lever to equipoise a force or pressure of 40 lbs. tending to raise the valve?

Set 5 upon C to 40 upon A; and against 20 upon C is 10 upon A.

3. If $8\frac{3}{4}$ yards of cloth, $1\frac{1}{2}$ yard in width, be a sufficient quantity, how much will be required of that which is only $\frac{7}{8}$ths in width, to effect the same purpose?

Set 1·5 upon C to 8·75 upon A; and against 8·75 upon C is 15 yards upon A.

Square and Cube Roots of Numbers.

On the engineer's rule, when the lines C and D are equal at both ends, C is a table of squares, and D a table of roots, as

Squares	1	4	9	16	25	36	49	64	81	on C.
Roots	1	2	3	4	5	6	7	8	9	on D.

To find the Geometrical mean Proportion between two Numbers.

Set one of the numbers upon C to the same number upon D; and against the other number upon C is the mean number or side of an equal square upon D.

Required the mean proportion between 20 and 45.

Set 20 upon C to 20 upon D; and against 45 upon C is 30 upon D.

To cube any number, set the number upon C to 1 or 10 upon D; and against the same number upon D is the cube number upon C.

Required the cube of 4.

Set 4 upon C to 1 or 10 upon D; and against 4 upon D is 64 upon C.

To extract the cube root of any number, invert the slide, and set the number upon B to 1 or 10 upon D; and where two numbers of equal value coincide on the lines B D, is the root of the given number.

Required the cube root of 64.

Set 64 upon B to 1 or 10 upon D; and against 4 upon B is 4 upon D, or root of the given number.

On the common rule, when 1 in the middle of the line C is set opposite to 10 on D, then C is a table of squares, and D a table of roots.

To cube any number by this rule, set the number upon C to 10 upon D; and against the same number upon D is the cube upon C.

Mensuration of Surface.

1. *Squares, Rectangles, etc.*

RULE.—When the length is given in feet and the breadth in inches, set the breadth on B to 12 on A; and against the length on A is the content in square feet on B.

If the dimensions are all inches, set the breadth on B to 144 upon A; and against the length upon A is the number of square feet on B.

Required the content of a board 15 inches broad and 14 feet long.

Set 15 upon B to 12 upon A; and against 14 upon A is 17·5 square feet on B.

2. *Circles, Polygons, etc.*

RULE.—Set ·7854 upon C to 1 or 10 upon D; then will the lines C and D be a table of areas and diameters.

Areas	3·14	7·06	12·56	19·63	28·27	38·48	50·26	63·61	upon C.
Diam.	2	3	4	5	6	7	8	9	upon D.

In the common rule, set ·7854 on C to 10 on D; then C is a line or table of areas, and D of diameters, as before.

Set 7 upon B to 22 upon A; then B and A form or become a table of diameters and circumferences of circles.

Cir.	3·14	6·28	9·42	12·56	15·7	18·85	22	25·13	28·27	upon A.
Dia.	1	2	3	4	5	6	7	8	9	upon B.

Polygons from 3 *to* 12 *sides.*—Set the gauge-point upon C to 1 or 10 upon D; and against the length of one side upon D is the area upon C.

Sides	3	5	6	7	8	9	10	11	12.
Gauge-points	·433	1·7	2·6	3·63	4·82	6·18	7·69	9·37	11·17.

Required the area of an equilateral triangle, each side 12 inches in length.

Set ·433 upon C to 1 upon D; and against 12 upon D are 62·5 square inches upon C.

Table of Gauge-Points for the Engineer's Rule.

NAMES.	F, F, F.	F, I, I.	I, I, I.	F, I.	I, I.	F.	I.
Cubic inches..	578	83	1728	106	1273	105	121
Cubic feet.....	1	144	1	1833	22	121	33
Imp. gallons..	163	231	277	294	353	306	529
Water in lbs.	16	23	276	293	352	305	528
Gold "	814	1175	141	149	178	155	269
Silver "	15	216	261	276	334	286	5
Mercury "	118	169	203	216	258	225	389
Brass "	193	177	333	354	424	369	637
Copper "	18	26	319	331	397	345	596
Lead "	141	203	243	258	31	27	465
Wro't iron "	207	297	357	338	453	394	682
Cast iron "	222	32	384	407	489	424	733
Tin "	219	315	378	401	481	419	728
Steel "	202	292	352	372	448	385	671
Coal "	127	183	22	33	28	242	42
Marble "	591	85	102	116	13	113	195
Freestone · "	632	915	11	1162	14	141	21

For the Common Slide Rule.

NAMES.	F, F, F.	F, I, I.	I, I, I.	F, I.	I, I.	F.	I.
Cubic inches..	36	518	624	660	799	625	113
Cubic feet.....	625	9	108	114	138	119	206
Water in lbs.	10	144	174	184	22	191	329
Gold "	507	735	88	96	118	939	180
Silver "	938	136	157	173	208	173	354
Mercury "	738	122	127	132	162	141	242
Brass "	12	174	207	221	265	23	397
Copper "	112	163	196	207	247	214	371
Lead "	880	126	152	162	194	169	289
Wro't iron "	129	186	222	235	283	247	423
Cast iron "	139	2	241	254	304	265	458
Tin "	137	135	235	25	300	261	454
Steel "	136	183	22	233	278	239	418
Coal "	795	114	138	146	176	151	262
Marble "	370	53	637	725	81	72	121
Freestone "	394	57	69	728	873	755	132

Mensuration of Solidity and Capacity.

General Rule. — Set the length upon B to the gauge-point upon A; and against the side of the square, or diameter on D, are the cubic contents, or weight in lbs. on C.

1. Required the cubic contents of a tree 30 feet in length, and 10 inches quarter girt.

Set 30 upon B to 144 (the gauge-point) upon A; and against 10 upon D is 20·75 feet upon C.

2. In a cylinder 9 inches in length, and 7 inches diameter, how many cubic inches?

Set 9 upon B to 1273 (the gauge-point) upon A; and against 7 on D is 346 inches on C.

3. What is the weight of a bar of cast iron 3 in. square and 6 ft. long?

Set 6 upon B to 32 (the gauge-point) upon A; and against 3 upon D is 168 pounds upon C.

By the Common Rule.

4. Required the weight of a cylinder of wrought iron 10 inches long and 5½ diameter.

Set 10 upon B to 283 (the gauge-point) upon A; and against 5½ upon D is 66·65 pounds on C.

5. What is the weight of a dry rope 25 yards long and 4 inches circumference?

Set 25 upon B to 47 (the gauge-point) upon A; and against 4 on D is 53·16 pounds on C.

6. What is the weight of a short-linked chain 30 yards in length, and $\frac{6}{16}$ of an inch in diameter?

Set 30 upon B to 52 (the gauge-point) upon A; and against 6 on D is 129·5 pounds on C.

Power of Steam Engines.

Condensing Engines. Rule. — Set 3·5 on C to 10 on D; then D is a line of diameters for cylinders, and C the corresponding number of horses' power; thus,

H. Pr.	3½	4	5	6	8	10	12	16	20	25	30	40	50	on C.
C. D.	10 in.	10¾	12	13¼	15½	17	18¾	21½	24	26¾	29½	33¾	37¾	on D.

The same is effected on the common rule by setting 5 on C to 12 on D.

Non-condensing Engines. Rule. — Set the pressure of steam in pounds per square inch on B to 4 upon A; and against the cylinder's diameter on D is the number of horses' power upon C.

Required the power of an engine, when the cylinder is 20 inches diameter and steam 30 pounds per square inch.

Set 30 on B to 4 on A; and against 20 on D is 30 horses' power on C.

The same is effected on the common rule by setting the force of the steam on B to 250 on A.

Of Engine Boilers.

How many superficial feet are contained in a boiler 23 feet in length and 5½ feet in width?

Set 1 on B to 23 on A; and against 5·5 upon B is 126·5 square feet upon A.

If 5 square feet of boiler surface be sufficient for each horse-power, how many horses' power of engine is the boiler equal to?

Set 5 upon B to 126·5 upon A; and against 1 upon B is 25·5 upon A.

Horse Power.

As this is the universal term used to express the capability of first movers, of magnitude, it is essential that the estimate of it should be uniform.

Its estimate is the elevation of 33,000 pounds avoirdupois one foot in height in one minute, and it is designated as being Nominal, Indicated, or Actual.

The first designation being adopted and referred to by Manufacturers of steam-engines in order to express the capacity of an engine, the elements thereof being confined to the dimensions of the steam cylinder, and a conventional pressure of steam and speed of piston; the second to designate the full capacity of an engine, as developed in operation, without any deduction for friction; and the last referring to its actual power as developed by its operation, involving the elements of the mean pressure upon the piston, its velocity, and a just deduction for the friction of the operation of the machine.

In reviewing the various modes for the computation as submitted by Engineers and Manufacturers, there is no proper formula that presents the essential element of being in conformity with any other, and as conformity in a rule for this purpose, if based upon an assimilation to the capacity of an engine, is all that is requisite, it would have been preferable to have adopted an existing formula to the introduction of a new one, had it been practicable to have done so. It occurs, further, that there is not only a want of conformity in the various rules essayed by authors, but they have neither reached the cases of both condensing and non-condensing engines, nor have they properly approached to the actual power of an engine; and as the practice of operating engines since the adoption of existing formulæ has materially altered, both in an increase of pressure and velocity of piston, the following rules are submitted.

Nominal Horse's Power.

CONDENSING ENGINE.

$\frac{d^2 v}{3000}$ = *horse's power; d representing diam. of cylinder in inches, and v the velocity of the piston in feet per minute.*

This is alike to the rule of the British Admiralty, substituting 3000 for 6000, and it is based upon a uniform steam pressure of 10 lbs. per square inch (steam gauge, or *above* the pressure of the atmosphere), cut off at one-half the stroke, deducting one-fifth* for friction and losses, with a mean velocity of piston of 250 feet per minute for an engine of long stroke, and of 200 feet for one of short stroke.

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* The friction and losses in a marine engine may be taken at 1·5 to 2 lbs. per square inch for working the engine, and 5 to 7½ per cent. upon the remainder for the friction of the load.

The rule of the British Admiralty is based upon a uniform and effective pressure of 7 lbs. per square inch at full stroke, and a mean velocity of piston of 205 feet per minute: viz., 170 feet for a stroke of 2·5 feet, and 240 feet for a stroke of 8 feet.

NON-CONDENSING ENGINE.

$$\frac{d^2\,v}{1000} = \textit{horse's power.}$$

This is based upon a uniform steam pressure of 60 lbs. per square inch (steam gauge), cut off at one-half the stroke, deducting one-sixth for friction and losses, with a mean velocity of piston of 250 feet per second.

Nominal Horse Power of several Non-condensing Engines.

Computed from Formula $\frac{d^2\,v}{1000} = \text{H. P.}$

Horses' Power.	Diameter and Stroke of Cylinder.		Revolutions.	Horses' Power.	Diameter and Stroke of Cylinder.		Revolutions.	Horses' Power.	Diameter and Stroke of Cylinder.		Revolutions.
No.	Ins.	Feet.	Min.	No.	Ins.	Feet.	Min.	No.	Ins.	Feet.	Min.
9·	6×	1·	125	46·1	12×	4·5	32	159·7	22×	5·5	30
9·2	6	1·5	85	55·3	14	3·	47	160·7	22	6·	28
12·2	7	1·	125	56·3	14	3·5	41	163·6	22	6·5	26
12·5	7	1·5	85	58·	14	4·	37	169·4	22	7·	25
16·3	8	1·5	85	60·	14	4·5	34	183·7	24	5·5	29
16·9	8	1·75	75	60·8	14	5·	30	193·5	24	6·	28
21·1	9	1·5	87	64·8	15	3·	48	194·7	24	6·5	26
21·3	9	1·75	75	66·1	15	3·5	42	193·5	24	7·	24
21·4	9	2.	66	66·6	15	4·	37	198·7	24	7·5	23
21·5	9	2·5	53	66·8	15	4·5	33	227·1	26	6·	28
26·1	10	1·5	87	67·5	15	5·	30	228·5	26	6·5	26
26.6	10	1·75	76	77·1	16	3·5	43	227·1	26	7.	24
27·2	10	2·	68	77·8	16	4·	38	233·2	26	7·5	23
27·5	10	2·5	55	78·3	16	4·5	34	237·9	26	8·	22
28·2	10	3·	47	79·4	16	5·	31	266·	28	6·5	26
28·7	10	3·5	41	81·7	16	5·5	29	274·4	28	7·	25
28·8	10	4·	36	82·9	16	6·	27	270·5	28	7·5	23
32·9	11	2·	70	99·1	18	4·5	34	275·8	28	8·	22
33·3	11	2·5	55	103·7	18	5·	32	279·9	28	8·5	21
33.4	11	3.	46	103·4	18	5·5	29	304·2	30	6·5	26
33.9	11	3·5	40	105·	18	6·	27	315·	30	7·	25
34·9	11	4.	36	128.	20	5·	32	324·	30	7·5	24
39·2	12	2·	68	127.6	20	5·5	29	331·2	30	8·	23
39·6	12	2·5	55	129·6	20	6·	27	336·6	30	8·5	22
40·6	12	3·	47	130·	20	6·5	25	340·2	30	9·	21
41·3	12	3·5	41	134·4	20	7·	24	359·1	30	9·5	21
41·5	12	4.	36	154·9	22	5·	32	360·	30	10·	20

Indicated Horse Power.

This is the gross power exerted by an engine, without any deduction for friction, the mean pressure upon the piston being determined by an Indicator, or by a computation based upon the actual initial pressure in the cylinder.

Mixture of Air and Steam.

Water contains a portion of air or other uncondensable gaseous matter, and when it is converted into steam, this air is mixed with it, and when the steam is condensed it is left in a gaseous state. If means were not taken to remove this air or gaseous matter from the condenser of a steam-engine, it would fill it and the cylinder, and obstruct their operation; but, notwithstanding the ordinary means of removing it (by the air-pump), a certain quantity of it always remains in the condenser.

20 volumes of water absorb 1 volume of air.

Steam Acting Expansively.

To Compute the mean Pressure of Steam upon a Piston by Hyperbolic Logarithms.

Rule.— Divide the length of the stroke of a piston, added to the clearance in the cylinder at one end, by the length of the stroke at which the steam is cut off, added to the clearance at that end, and the quotient will express the relative expansion of the steam or *number*.

Find in the table the logarithm of the *number* nearest to that of the quotient, to which add 1. The sum is the ratio of the gain.

Multiply the ratio thus obtained by the pressure of the steam (including the atmosphere) *as it enters the cylinder*, divide the product by the relative expansion, and the quotient will give the mean pressure required.

Table of Hyperbolic Logarithms.

No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1·05	·049	2.65	·975	4·25	1·447	5·8	1·758	7·4	2·001
1·1	·095	2·66	·978	4·3	1·459	5·85	1·766	7·45	2·008
1·15	·14	2·7	·993	4·33	1·465	5·9	1·775	7·5	2·015
1·2	·182	2·75	1·012	4·35	1·47	5·95	1·783	7·55	2·022
1·25	·223	2·8	1·03	4·4	1·482	6·	1·792	7·6	2·028
1·3	·262	2·85	1·047	4·45	1·493	6·05	1·8	7·65	2·035
1·33	·285	2·9	1·065	4·5	1·504	6·1	1·808	7·66	2·036
1·35	·3	2·95	1·082	4·55	1·515	6·15	1·816	7·7	2·041
1·4	·336	3·	1·099	4·6	1·526	6·2	1·824	7·75	2·048
1·45	·372	3·05	1·115	4·65	1·537	6·25	1·833	7·8	2·054
1·5	·405	3·1	1·131	4·66	1·54	6·3	1·841	7·85	2·061
1·55	·438	3·15	1·147	4·7	1·548	6·33	1·845	7·9	2·067
1·6	·47	3·2	1·163	4·75	1·558	6·35	1·848	7·95	2·073
1·65	·5	3·25	1·179	4·8	1·569	6·4	1·856	8·	2·079
1·66	·506	3·3	1·194	4·85	1·579	6·45	1·864	8·05	2·086
1·7	·531	3·33	1·202	4·9	1·589	6·5	1·872	8·1	2·092
1·75	·56	3·35	1·209	4·95	1·599	6·55	1·879	8·15	2·098
1·8	·588	3·4	1·224	5·	1·609	6·6	1·887	8·2	2·104
1·85	·612	3·45	1·238	5·05	1·619	6·65	1·895	8·25	2·11
1·9	·642	3·5	1·253	5·1	1·629	6·66	1·896	8·3	2·116
1·95	·668	3·55	1·267	5·15	1·639	6·7	1·902	8·33	2·119
2·	·693	3·6	1·281	5·2	1·649	6·75	1·91	8·35	2·122
2·05	·718	3·65	1·295	5·25	1·658	6·8	1·917	8·4	2·128
2·1	·742	3·66	1·297	5·3	1·668	6·85	1·924	8·45	2·134
2·15	·765	3·7	1·308	5·33	1·673	6·9	1·931	8·5	2·14
2·2	·788	3·75	1·322	5·35	1·677	6·95	1·939	8·55	2·146
2·25	·811	3·8	1·335	5·4	1·686	7·	1·946	8·6	2·152
2·3	·833	3·85	1·348	5·45	1·696	7·05	1·953	8·65	2·158
2·33	·845	3·9	1·361	5·5	1·705	7·1	1·96	8·66	2·159
2·35	·854	3·95	1·374	5·55	1·714	7·15	1·967	8·7	2·163
2·4	·875	4·	1·386	5·6	1·723	7·2	1·974	8·75	2·169
2·45	·896	4·05	1·399	5·65	1·732	7·25	1·981	8·8	2·175
2·5	·916	4·1	1·411	5·66	1·733	7·3	1·988	8·85	2·18
2·55	·936	4·15	1·423	5·7	1·74	7·33	1·991	8·9	2·186
2·6	·956	4·2	1·435	5·75	1·749	7·35	1·995	8·95	2·192

NOTE.—The Hyp. Log. of any number not in the table may be found by multiplying a common log. by 2·302585053, usually by 2·3.

Example.—Assume steam to enter a cylinder at a pressure of 34·7 lbs. per square inch, and to be cut off at $\frac{1}{4}$ the length of the stroke of the piston, the stroke being 10 feet; what will be the mean pressure?

10 feet + ·5 for clearance = 120·5 *ins.*, stroke 10 ÷ 4 + ·5 for clearance = 30·5 *ins.*

Then 120·5 ÷ 30·5 = 3·95, *the relative expansion.*

Log. of number 3·95 = 1·374, which + 1 = 2·374.

$$\frac{2{\cdot}374 \times 34{\cdot}7}{3{\cdot}95} = \frac{82{\cdot}3778}{3{\cdot}95} = 20{\cdot}855 \text{ lbs.}$$

When the Relative Expansion or Number falls between two numbers in the Table, proceed as follows: Take the difference between the logs. of the two numbers. Then, as the difference between the numbers is to the difference between these logs., so is the excess of the expansion over the least number, which, added to the least log., will give the log. required.

Illustration. — The expansion is 4·84, the logs. for 4·8 and 4·85 are 1·569 and 1·579, and their difference ·01. Hence, as 4·85 ∽ 4·8 = ·05 : 1·579 ∽ 1·569 = ·01 : : 4·84 — 4·8 = ·04 : ·008, and 1·569 + ·008 = 1·577 = *the log. required.*

Effect of Expansion with Equal Volumes of Steam.

The theoretical economy of using steam expansively is as follows — a like volume of steam being expended in each case, and expanded to fill the increased spaces.

Point of Cutting Off.	Expansion Number.	Mean Pressure of Steam.	Gain per Cent. in Power.	Point of Cutting Off.	Expansion Number.	Mean Pressure of Steam.	Gain per Cent. in Power.
·1	10·	3·302	230·	·5	2·	1·693	69·3
·125	8·	3·079	208·	·6	1·66	1·507	50·7
·166	6·	2·791	179·	·625	1·6	1·47	47·
·2	5.	2·609	161·	·666	1·5	1·405	40·5
·25	4·	2·386	139·	·7	1·42	1·351	35·1
·3	3·33	2·203	120·	·75	1·33	1·285	22·3
·333	3·	2·099	110·	·8	1·25	1·223	20·5
·375	2.66	1·978	97·8	·875	1·143	1·131	13·1
·4	2·5	1·916	91·6	·9	1·11	1·104	10·4

In this illustration, no deductions are made for a reduction of the temperature of the steam while expanding or for loss by back pressure.

The same relative advantage follows in expansion as above given, whatever may be the initial pressure of the steam.

Gain in Fuel, and Initial Pressure of Steam required, when acting Expansively, compared with Non-Expansion or Full Stroke.

Point of Cutting Off.	Gain in Fuel.	Initial Pressure Required.		Point of Cutting Off.	Gain in Fuel.	Initial Pressure Required.	
		Cutting Off.	Full Stroke.			Cutting Off.	Full Stroke.
Stroke.	Per Cent.	Lbs.	Lbs.	Stroke.	Per Cent.	Lbs.	Lbs.
$\frac{7}{8}$	11·7	1·01	1·	$\frac{3}{8}$	49·6	1·32	1·
$\frac{3}{4}$	22·4	1·03	1·	$\frac{1}{4}$	58·2	1·67	1·
$\frac{5}{8}$	32·	1·09	1·	$\frac{1}{8}$	67·6	2·6	1·
$\frac{1}{2}$	41·	1·18	1·				

The *Relative Effect* of Steam during Expansion is obtained from the preceding rule.

The *Mechanical Effect* of Steam in a cylinder is the product of the mean pressure in lbs., and the distance through which it has passed in feet.

The *Pressure at the End of a Stroke*, or *at any Given Point of the Stroke*, is obtained by dividing the initial pressure by the portion of the stroke performed when the steam is cut off.

Slide-Valves.

All Dimensions in Inches.

To Compute how much Lap must be given on the Steam Side of a Slide-Valve to cut off the Steam at any given Part of the Stroke of the Piston.

Rule.—From the length of stroke of piston subtract the length of the stroke that is to be made before the steam is cut off; divide the remainder by the stroke of the piston, and extract the square root of the quotient. Multiply this root by half the throw of the valve, from the product subtract half the lead, and the remainder will give the lap required.

Example.—Having stroke of piston 60 inches, stroke of valve 16 inches, lap upon exhaust side $\frac{1}{2}$ inch = $\frac{1}{32}$ of valve stroke, lap upon steam side $3\frac{1}{4}$ inches, lead 2 inches, steam to be cut off at $\frac{5}{6}$ the stroke; what is the lap?

$$60 - \frac{5}{6} \text{ of } 60 = 10 \cdot \quad \frac{10}{16} = \cdot 166. \quad \sqrt{\cdot 166} = 408. \quad \cdot 408 \times \frac{16}{2} = 3\cdot 264,$$

and $3\cdot264 - \frac{2}{2} = 2\cdot264$ *inches or the lap — half the lead.*

To Compute the Lap required on the Steam Side of a Valve, to cut the Steam off at various Portions of the Stroke of the Piston.

Valve without Lead.

	Distance of the piston from the end of its stroke when the steam is cut off, in parts of the length of its stroke.									
	$\frac{1}{2}$	$\frac{5}{12}$	$\frac{1}{3}$	$\frac{7}{24}$	$\frac{1}{4}$	$\frac{5}{24}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{12}$	$\frac{1}{24}$
Lap in parts of the stroke....	·354	·323	·286	·27	·25	·228	·204	·177	·144	·102

Illustration.—Take the elements of the preceding case.

Under $\frac{1}{6}$ is ·204, and ·204 × 16 = 3·264 *inches lap.*

When the Valve is to have Lead.—Subtract half the proposed lead from the lap ascertained by the table, and the remainder will be the proper lap to give to the valve.

If, therefore, as in the last case, the valve was to have 2 inches lead, then $2 \div 2 - 3\cdot264 = 2\cdot264$ *inches.*

Portion of the Stroke of a Piston at which the Exhausting Port is closed and opened.

Lap on the Exhaust Side of the Valve in Parts of its throw.

Lap.	Portion of Stroke at which the Steam is cut off.							
	$\frac{1}{3}$	$\frac{7}{24}$	$\frac{1}{4}$	$\frac{5}{24}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{12}$	$\frac{1}{24}$
A								
$\frac{1}{8}$	·178	·161	·143	·126	·109	·093	·074	·053
$\frac{1}{16}$	·13	·118	·1	·085	·071	·058	·043	·027
$\frac{1}{32}$	·113	·101	·085	·069	·053	·043	·033	·024
0	·092	·082	·067	·055	·041	·033	·022	·011
B								
$\frac{1}{8}$	·033	·026	·019	·012	·008	·004	·001	·001
$\frac{1}{16}$	·06	·052	·04	·03	·022	·015	·008	·002
$\frac{1}{32}$	·073	·066	·051	·042	·033	·023	·013	·004
0	·092	·082	·067	·055	·044	·033	·022	·011

The units in the columns of the table marked A express the distance of the piston, in parts of its stroke, from the end of the stroke when the exhaust port in advance of it is closed; and those in the columns of the table marked B express the distance of the piston, in parts of its stroke, from the end of its stroke when the exhaust port behind it is opened.

Illustration.—A slide-valve is to cut off at $\frac{1}{6}$ from the end of the stroke of the piston, the lap on the exhaust side is $\frac{1}{32}$ of the stroke of the valve (16 inches), and the stroke of the piston is 60 inches. At what point of the stroke of the piston will the exhaust port in advance of it be closed, and the one behind it opened?

Under $\frac{1}{6}$ in table A, opposite to $\frac{1}{32}$. is ·053, which × 60, the length of the stroke $= 3{\cdot}18$ *inches;* and under $\frac{1}{6}$ in table B, opposite to $\frac{1}{32}$, is ·033, which × $60 = 1{\cdot}98$ *inches.*

If the lap on the exhaust side of this valve was increased, the effect would be to cause the port in advance of the valve to be closed sooner, and the port behind it opened later. And if the lap on the exhaust side was removed entirely, the port in advance of the piston would be shut, and the one behind it open, at the same time.

The lap on the steam side should always be greater than that on the exhaust side, and the difference greater the higher the velocity of the piston.

In fast-running engines alike to locomotives, it is necessary to open the exhaust valve before the end of the stroke of the piston, in order to give more time for the escape of the steam.

To Ascertain the Breadth of the Ports.

Half the throw of the valve should be at least equal to the lap on the steam side, added to the breadth of the port. If this breadth does not give the required area of port, the throw of the valve must be increased until the required area is attained.

To Compute the Stroke of a Slide-Valve.

Rule.—To twice the lap add twice the width of a steam port in inches, and the sum will give the stroke required.

Expansion by lap, with a slide-valve operated by an eccentric alone, cannot be extended beyond $\frac{1}{3}$ of the stroke of a piston without interfering with the efficient operation of the valve; with a link motion, however, this distortion of the valve is somewhat compensated. When the lap is increased, the throw of the eccentric should also be increased.

When low expansion is required, a cut-off valve should be resorted to in addition to the main valve.

To Compute the Lap and Lead of Locomotive Valves.

$\cdot 32\,t =$ *lap in inches,* and $\cdot 07\,t =$ *lead in inches; t representing the stroke of the valve.*

Giffard's Injector.

Maximum Temperature of the Feed-water Admissible at different Pressures of Steam.

	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Pressure per square inch...	10	20	30	40	50	100
Temperature of feed.........	148°	138°	130°	124°	120°	110°

The capacities of injectors are denoted by the diameters of their *throats* in millimetres; thus No. 4 has a diameter of 4 millimetres $= 4 \times \cdot 0394 = \cdot 1576$ *inches.*

The expenditure of steam increases with the proportionate pressure in the boiler.

Raising the Safety-Valve of a Boiler will lessen the pressure by allowing the steam to escape from the boiler, thus permitting the water to rise up and come in contact with the over-heated iron, and probably cause an explosion.

The Door and Damper should never be open at the same time, unless it is absolutely necessary, as the cold air, that would otherwise have to pass through the fire and become rarified, rushes through the open door above the fire, and impinges on the tube and crown-sheets, and has a tendency to contract the seams and cause them to leak.

Blowing out the Boiler under a high steam pressure, the change is so sudden that it has a tendency to contract the iron, and cause the boiler to leak.

To heat Rooms, 1 square foot of steam-pipe surface is required for 80 cubic feet of space; 1 cubic foot of boiler is required for 1500 cubic feet of space. One horse-power boiler is sufficient for 40,000 cubic feet of space.

BELTS.

The resistance of belts to slipping is independent of their breadth, consequently there is no advantage derived in increasing this dimension beyond that which is necessary to enable the belt to resist the strain it is subjected to.

The ratio of friction to pressure for belts over wood drums, is, for leather belts, when worn, ·47; when new, ·5; and when over turned cast-iron pulleys, ·24 and ·27.

A leather belt will safely and continuously resist a strain of 350 lbs. per square inch of section, and a section of ·2 of a square inch will transmit the equivalent of a horse's power at a velocity of 1000 feet per minute over a wooden drum, and ·4 of a square inch over a turned cast-iron pulley.

A vulcanized India-rubber belt will sustain a greater stress than leather, added to which its resistance to slipping is from 50 to 85 per cent. greater.

In high speed belting, the tension, or the breadth of the belt, should be increased, in order to prevent the belt from slipping. Long belts are more effective than short ones.

To Compute the Stress a Belt or Cord is capable of transmitting.—*Aide Memoire.*

Rule.—Multiply the *value* of C from the following table by the stress in pounds.

Proportion of Arc embraced to the Circumference of the Driving Pulley.	Value of Coefficient C.			
	Leather Belts.		Cords on Wooden Sheaves.	
	On Wood Drums.	On Iron Pulleys.	Rough.	Polished.
·2	1·8	1·4	1·9	1·5
·3	2·4	1·7	2·6	1·9
·4	3·3	2·	3·5	2·3
·5	4·4	2·4	4·8	2·8
·6	5·9	2·9	6·6	3·5
·7	7·9	3·4	9·	4·2

C = *the ratio of the resistance of a drum or pulley to slipping a belt or cord when the resistance of the belt or cord upon the under or slack side is known.*

Example.—What is the stress a belt is capable of transmitting when the arc embraced upon the surface of the driving and wooden drums is ·4 of its circumference, and the power or tension of the belt is 200 lbs.?

$$3{\cdot}3 \times 200 = 660 \text{ } lbs.$$

To Compute the Stress which is transmitted to a Belt or Cord.

Rule.— Divide the power in pounds transmitted to the periphery of the pulley by the velocity of the surface of the drum.

Example.— A cast-iron pulley, 4 feet in diameter, driven by a power of four horses, makes 160 revolutions per minute; what is the stress upon the belt?

$33{,}000 \times 4 = 132{,}000$ *lbs. 1 foot per minute.*

$4 \times 3{\cdot}1416 \times 100 = 1256{\cdot}64$ *feet velocity.*

Then $\frac{132000}{1256{\cdot}64} = 105$ *lbs.* = *difference of the stress upon the belt and the resistance of the under side of it,* $\frac{S}{C-1} = S$, and $S + s = P$. P *representing the stress transmitted by a belt, s the resistance of its under side,* and P *the sum of* $S + s$, *or the stress and resistance.*

Illustration.— What should be the resistance of the under side of a leather belt running over the semi-circumference of a cast-iron pulley, 1 foot in diameter, driven by a power of 200 lbs.?

$$\frac{200}{2{\cdot}4 - 1} = 142{\cdot}85 \text{ lbs.}$$

LIMES, CEMENTS, MORTARS, AND CONCRETES.

Turkish Plaster, or Hydraulic Cement.—100 lbs. fresh lime reduced to powder, 10 quarts linseed-oil, and 1 to 2 ounces cotton. Manipulate the lime, gradually mixing the oil and cotton, in a wooden vessel, until the mixture becomes of the consistency of bread-dough.

Dry, and, when required for use, mix with linseed-oil to the consistency of paste, and then lay on in coats. Water-pipes of clay or metal, joined or coated with it, resist the effect of humidity for very long periods.

Exterior Plaster or Stucco.— 1 volume of cement powder to 2 volumes of dry sand.

In India, to the water for mixing the plaster is added 1 lb. of sugar. or molasses, to 8 Imperial gallons of water, for the first coat; and for the second or finishing, 1 lb. sugar to 2 gallons water.

Powdered slaked lime and Smith's forge scales, mixed with blood in suitable proportions, make a moderate hydraulic mortar, which adheres well to masonry previously coated with boiled oil.

The plaster should be applied in two coats laid on in one operation, the first coat being thinner than the second. The second coat is applied upon the first while the latter is yet soft.

The two coats should form one of about 1½ inches in thickness, and when finished it should be kept moist for several days.

This process may be modified by substituting for the first coat a wash of thick cream of pure cement, applied with a stiff brush just before the plaster is laid on.

When the cement is of too dark a color for the desired shade, it may be mixed with white sand in whole or in part, or lime paste may be added until its volume equals that of the cement paste.

Khorassar, or Turkish Mortar, used for the construction of buildings requiring great solidity, $\frac{1}{3}$ powdered brick and tiles, $\frac{2}{3}$ fine sifted lime. Mix with water to the required consistency, and lay on layers of 5 and 6 inches in thickness between the courses of brick or stones.

Interior Plastering.— The mortars used for inside plastering are termed Coarse, Fine, Gauge or hard finish, and Stucco.

Coarse Stuff. — Common lime mortar, as made for brick masonry, with a small quantity of hair; or by volumes, lime paste (30 lbs. lime) 1 part, sand 2 to $2\frac{1}{4}$ parts, hair $\frac{1}{6}$ part.

When full time for hardening cannot be allowed, substitute from 15 to 20 *per cent.* of the lime by an equal proportion of hydraulic cement.

For the second or *brown coat* the proportion of hair may be slightly diminished.

Fine Stuff (lime putty). — Lump lime slaked to a paste with a moderate volume of water, and afterwards diluted to the consistency of cream, and then to harden by evaporation to the required consistency for working.

In this state it is used for a *slipped coat*, and when mixed with sand or plaster of Paris, it is used for the *finishing coat.*

Gauge Stuff, or Hard finish, is composed of from 3 to 4 volumes fine stuff and 1 volume plaster of Paris, in proportions regulated by the degree of rapidity required in hardening; for cornices, etc., the proportions are equal volumes of each, fine stuff and plaster.

Stucco is composed of from 3 to 4 volumes of white sand, to 1 volume of fine stuff, or lime putty.

Scratch Coat.— The first of three coats when laid upon laths, and is from $\frac{1}{4}$ to $\frac{3}{8}$ of an inch in thickness.

One-coat Work.—Plastering in one coat without finish, either on masonry or laths — that is, *rendered* or *laid.*

Two-coat Work.— Plastering in two coats is done either in a *laying coat and set*, or in a *screed coat and set.*

The **Screed coat** is also termed a *Floated coat. Laying* the first coat in two-coat work is resorted to in common work instead of *screeding*, when the finished surface is not required to be exact to a straight-edge. It is laid in a coat of about $\frac{1}{2}$ an inch in thickness.

The laying coat, except for very common work, should be *hand-floated.*

The firmness and tenacity of plastering is very much increased by hand-floating.

Screeds are strips of mortar 6 to 8 inches in width, and of the required thickness of the first coat, applied to the angles of a room, or edge of a wall and parallelly, at intervals of 3 to 5 feet over the surface to be covered. When these have become sufficiently hard to withstand the pressure of a straight-edge, the inter-spaces between the screeds should be filled out flush with them, so as to produce a continuous and straight, even surface.

Slipped Coat is the smoothing off of a brown coat with a small quantity of lime putty, mixed with 3 per cent. of white sand, so as to make a comparatively even surface.

This finish answers when the surface is to be finished in distemper, or paper.

Hard Finish.— Fine stuff applied with a trowel to the depth of about ⅛ of an inch.

Estimate of Materials and Labor for 100 Square Yards of Lath and Plaster.

Materials and Labor.	3 Coats Hard Finish.	Two Coats Slipped.	Materials and Labor.	3 Coats Hard Finish.	Two Coats Slipped.
Lime..........	4 casks.	3½ casks.	White sand..	2½ bush.	
Lump lime..	⅔ "		Nails..........	13 lbs.	13 lbs.
Plast. Paris..	½ "		Masons	4 days.	3½ days.
Laths	2000.	2000.	Laborer	3 "	2 "
Hair...........	4 bush.	3 bush.	Cartage.......	1 "	¾ "
Sand	7 loads.	6 loads.			

Hydraulic.— 1½ parts unslacked hydraulic lime, 1½ parts sand, 1 part gravel, and 2 parts of a hard broken limestone.

This mass contracts one-fifth in volume. Fat lime may be mixed with concrete without serious prejudice to its hydraulic energy.

Various Compositions of Concrete. — Forts Richmond and Tompkins, U. S.

Hydraulic. — 308 lbs. cement = 3·65 to 3·7 cubic feet of stiff paste. 12 cubic feet of loose sand = 9·75 cubic feet of dense.

For Superstructure.— 11·75 cubic feet of mortar as above, and 16 cubic feet of stone fragments.

In the foundations of Fort Tompkins, about $\frac{1}{12}$ of its volume was composed of stones from ¼ to ¾ of a cubic foot in volume, rammed into the wall as the concrete was laid.

Sea Wall.— *Boston Harbor.— Hydraulic.*— 308 lbs. cement, 8 cubic feet of sand, and 30 cubic feet of gravel. The whole producing 32·3 cubic feet.

Superstructure.— 308 lbs. cement, 80 lbs. lime, and 14·6 cubic feet dense sands. The whole producing 12·825 cubic feet.

Cost of labor and materials expended in laying concrete foundation at Fort Tompkins, during the year 1849, per cubic yard as laid, $2.26.

Transverse Strength

Of Concretes, Cements, Mortars, Puzzuolana, and Trass, deduced from the Experiments of Generals Totten and Gillmore, U. S. A., General Treussart, and M. Voisin.

Reduced to a uniform Measure of One Inch Square and One Foot in Length. Supported at both Ends.

$\frac{2}{3}\,\frac{l\,W}{4\,b\,d^2} = V$ *per square inch of section, representing value for general use, being ⅔ of ultimate breaking strain.*

Experiments of Voisin, 1857.

Mortar.			Concrete.				Mortar.			Concrete.			
One Volume of Sand.		Volume produced.	One Volume of Pebbles.		Value.		One Volume of Sand.		Volume produced.	One Volume of Pebbles.		Value.	
Cement.	Water.		Mortar.	Volume produced.	10 Days.	60 Days.	Cement.	Water.		Mortar.	Volume produced.	10 Days.	60 Days.
					Lbs.	Lbs.						Lbs.	Lbs.
1	·62	1·69	1	1·56	2·3	2 9	⅓	·38	1·12	½	1·03	·58	1·2
			½	1·03	1·7	3·2	¼	·35	1·05	1	1·4	·48	1·
			⅓	1·	1·8	3·1				½	1·01	·35	·85
			¼	1·	1·	1·	⅕	·34	1·	1	1·45	·3	·83
½	·43	1·24	1	1·45	1·6	2·7				½	1·03	·44	·65
			½	1·	1·	1·9	⅙	·32	·96	1	1·45	·41	·81
⅓	·83	1·12	1	1·4	·86	·91				½	1·03	·26	·79

Experiments of General Totten, 1837.

Concrete. *	Mortar.			Concrete. *	Mortar.		
	Cement 1.	Cement 1. Sand ·5.	Cement 1. Sand 1.		Cement 1.	Cement 1. Sand ·5.	Cement 1. Sand 1.
	Lbs.	Lbs.	Lbs.		Lbs.	Lbs.	Lbs.
Granite ..1 Mortar...1	2·9	2·4	2·3	Stone...... Gravel.....	1·9	1·	·6
Gravel ...1 Mortar...2	1·4	2·4	·7	Brick....... Gravel.....	·9	1·4	1·6

*·The granite, bricks, etc., were broken into fragments or spalls of the required size.

Tensile Strength

Of various Cements, Mortars, and Masonry, deduced from the Experiments of Vicat and Chatoney at Cherbourg, Gen. Gillmore, U. S. A., Crystal Palace, London, etc.

Weight or Power required to Tear asunder One Square Inch.

Materials and Mixtures.	Ultim. Resistance.	Materials and Mixtures.	Ultim. Resistance.
	Lbs.		Lbs.
Boulogne, 100 parts, water 50.......	112	Portland, English, 320 days, cement 1, sand 2.......	713
90 days, 100 parts, water 50...........	52	" 45 days, pure and mixed, stiff............	206
Boulogne, 1 year, Portland (natural)	675	" English, pure, 1 month	393
English, 1 year, Portland (artificial)..	462	" " " 6 mos....	424
Portland, 42 days, cement 1, sand 1	142	Roman, 1 year, from Septaria..	191
" 15 "	134	" 42 days, cement 1, sand 1	284
" 135 "	233	" " " 1, " 2	199
" English, 320 days, pure...	1152	" " " 1, " 3	166
" " " cement 1, sand 1,	948	Stonemasonry, Roman cement, 5 mos..................................	77

Brick and Granite Masonry, 320 Days.		Lbs.
Cement, Delafield and Baxter	Pure	68·56
	Cement 4 Sand 1	68·5
	Cement 5 Siftings 1	79·87
	Cement 1 Siftings 2	74·5
" Lawrence Co.	Pure	87·37
	Pure	53·68
" James River	Cement 4 Sand 1	62·
" Newark Lime and Cement Co.	Pure	93·25
	Cement 1 Sand 2	39·62
" Brighton and Rosendale	Pure	80·25
" Newark and Rosendale	Pure	75·81
" Pure upon bricks		31·
" 1, sand 1 pure upon bricks		16·
" 1, " 3 " "		7·
" Pure upon granite		27·
" 1, water ·5		20·
" 1, " ·42		27·
" Pure upon bricks, without mortar, mean		45·
Common lime 1 " sand 2½	"	6·
Lime paste 1 Sand 3	upon bricks	6·
Lime paste 1 Sand 2	"	4·13
Lime paste 1 Sand 3 Cement paste 5	"	11·41

Crushing Strength of Cements, Stone, etc.

(*Crystal Palace, London.*)

Reduced to a uniform Measure of One Square Inch.

Material.	Ultimate Pressure.	Material.	Ultimate Pressure.
	Lbs.		Lbs.
Portland cement, area 1, height 1	1680	Portland cement 1 " sand 4	1244
" cement " sand	1244	Roman cement, pure	342

Experiments of General Gillmore.

Materials.	Cements and Mixtures.	Value.	Materials.	Cements and Mixtures.	Value.
		Lbs.			Lbs.
Delafield and Baxter	Stiff paste	6·*	Portland Pure (Eng.), 100 days	Cement ... 1 Sand ... 1	12·5 13·
High Falls (N. Y.), 270 days	Pure	11·3		Cement 1 Sand ... 2	8·5
James River	Cement Sand	5·9	Roman (Eng.), 100 days	Cement 1 Sand ... 1	4·
James River, 59 days	Cement ... 4· Water ... 2·6	1·9	Rosendale, 95 days	Pure	7·
	Cement ... 4· Water ... 1·4	3·4*		Cement 1 Lime ... ¼	6·7
Portland (Eng.), 320 days	Pure cement	10·6		Cement 1 Lime ... 1	3·9
	Cement ... 1 Sand ... 2	6·6	Rosendale (Hoffman), 320 days	Stiff paste...	4·4*
				Thin " ...	4·8*

* All except the first were submitted to a pressure of 32 lbs. per square inch.

Cement.	Value.			Cement.	Value.		
	Pure.	Cement 1. Sand 1.	Cement 1. Sand 2.		Pure.	Cement 1. Sand 1.	Cement 1. Sand 2.
		Lbs.	Lbs.			Lbs.	Lbs.
Akron, New York	5·2	4·4	4·1	Round Top, Md	...	4·1	...
Brighton and Rosendale	4·9	3·8	3·4	Rosendale, Hoffman	5·8	4·1	...
Cumberland, Md	6·5	6·3	3·8	" Lawrence	5·3	...	...
James River, Va	...	4·2	4·4	Sandusky, Ohio	3·8	3·2	...
Newark and Rosendale	5·8	3·8	3·4	Shepherdstown, Va	5·1	4·2	3·1
Portland, English	10·5	8·6	6·5	Utica, Ill	5·1	1·2	3·8
Remington, Conn	6·5	4·8	3·4				

NOTE.—When the paste is not subjected to compression during setting, a thin paste produces as strong a mortar as a stiff one.

Experiments of General Treussart.

Puzzuolana and Trass—Mortar.			Valne.	Puzzuolana and Trass—Mortar.			Value.
			Lbs.				Lbs.
Strasburgh	Puzzuolana 1 Sand ... 1 Trass ... 1	5 days	2·8	Strasburgh	Lime paste. 1 Puzzuolana 2½	5 days	3·8
	Lime ... 1 Sand ... 1 Puzzuolana 1	4 "	3·4		Lime paste. 1 Trass ... 2	8 "	3·1
				White Marble	Lime ... 1 Sand ... 1 Trass ... 1	5 "	2·1

Cement paste, 95 days	13·8	Cement paste ½, lime paste 1	4·2
" 1, lime paste ¼	13·6	Fire-brick beam †	2·1
" 1, " ½	11·3	Portland cement, 4 mos	21·3
" 1, " 1	7·9	Roman " 4 "	14·8

DEDUCTIONS.—1. Particles of unground cement exceeding $\frac{1}{80}$ of an inch in diameter may be allowed in cement paste without sand, to the extent of 50 per cent. of the whole, without detriment to its properties, while a corresponding proportion of sand injures the strength of mortar about 40 per cent.

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† Loaded partly along the bricks, and broke through them.

2. When these unground particles exist in cement paste to the extent of 66 per cent. of the whole, the adhesive strength is diminished about 28 per cent. For a corresponding proportion of sand the diminution is 68 per cent.

3. The addition of siftings exercises a less injurious effect upon the cohesive than upon the adhesive property of cement. The converse is true when sand, instead of siftings, is used.

4. In all the mixtures with siftings, even when the latter amounted to 66 per cent. of the whole, the cohesive strength of the mortars exceeded its adhesion to the bricks. The same results appear to exist when the siftings are replaced by sand, until the volume of the latter exceeds 20 per cent. of the whole, after which the adhesion exceeds the cohesion.

5. At the age of 320 days (and perhaps considerably within that period) the cohesive strength of pure cement mortar exceeds that of Croton front bricks. The converse is true when the mortar contains 50 per cent. or more of sand.

6. When cement is to be used without sand, as may be the case when *grouting* is resorted to, or when old walls are to be repaired by injections of thin paste, there is no advantage in having it ground to an impalpable powder.

7. For economy it is customary to add lime to cement mortars, and this may be done to a considerable extent when in positions where hydraulic activity and strength are not required in an eminent degree.

Slaking.— The volume of water required to slake lime will vary with limes from 2·5 to 3 times the volume of the lime (quicklime), and it is important that all the water required to reduce the lime to a proper consistency should be given to it before the temperature of the water first given becomes sensibly elevated.

Immediately upon the lime being provided with the requisite volume of water, it should be covered, in order to confine the heat, and it should not be stirred while slaking. When the paste is required for *grouting* or *whitewashing*, the water required should be given at once, and in larger volume than when the paste is required for mortar, and when slaked the mass should be transferred to tight casks to prevent the loss of water. When the character of the limes, as with those of hydraulic energy, will not readily reduce, their reduction, which is an indispensable condition, must be aided by mechanical means, as a mortar mill.

The process here given is termed *drowning*. When the lime is retained in a barrel, or like instrument, immersed in water, and then withdrawn before reduction occurs, it is termed *immersion*, and when it is reduced by being exposed to the atmosphere, and gradually absorbing moisture therefrom, it is termed *air-slaked*.

Bricks should be well wetted before use. *Sea sand* should not be used in the composition of mortar, as it contains salt and its grains are round, being worn by attrition, and consequently having less tenacity than sharp-edged grains.

Fine Clay.—The fusibility of clay arises from the presence of impurities, such as lime, iron, and manganese. These may be removed by steeping the clay in hot muriatic acid, then washing it with water. Crucibles from common clay may be made in this manner.

Pisé is made of clay or earth rammed in layers of from 3 to 4 inches in depth. In moist climates, it is necessary to protect the external surface of a wall constructed in this manner with a coat of mortar.

Asphalt Composition.—Mineral pitch 1 part, bitumen 11, powdered stone, or wood ashes, 7 parts.

2. Ashes 2 parts, clay 3 parts, and sand 1 part, mixed with a little oil, makes a very fine and durable cement, suitable for external use.

Mastic.—Pulverized burnt clay 93 parts, litharge ground very fine 7 parts, mixed with a sufficient quantity of pure linseed oil.

3. Silicious sand 14, pulverized calcareous stone 14, litharge 2, and linseed oil 4 parts by weight.

The powders to be well dried in an oven, and the surface upon which it is to be applied must be saturated with oil.

4. *For Roads.*—Bitumen 16·875 parts, asphaltum 225 parts, oil of resin 6·25 parts, and sand 135 parts. Thickness, from 1¼ to 1⅝ inches.

Asphaltum 55 lbs. and gravel 28·7 lbs. will cover an area of 10·75 square feet.

Notes by General Gillmore, U. S. A.—All the lime necessary for any required quantity or *batch* of mortar should be slaked at least one day before it is mixed with the sand.

All the water required to slake the lime should be poured on at one time, the lime should be submerged, and the mass should then be covered with a tarpaulin or canvas, and allowed to remain undisturbed for a period of 24 hours.

The ingredients should be thoroughly mixed, and then heaped for use as required.

Recent experiments have developed that most American cements will sustain, without any great loss of strength, a dose of lime paste equal to that of the cement paste, while a dose equal to ½ to ¾ the volume of cement paste may be safely added to any Rosendale cement without producing any essential deterioration of the quality of the mortar. Neither is the hydraulic activity of the mortars so far impaired by this limited addition of lime paste as to render them unsuited for concrete under water, or other submarine masonry. By the use of lime is secured the double advantages of slow setting and economy.

Pointing Mortar is composed of a paste of finely-ground cement and clean sharp silicious sand, in such proportions that the volume of cement paste is slightly in excess of the volume of voids or spaces in the sand. The volume of sand varies from 2½ to 2¾ that of the cement paste, or by weight, 1 of cement powder to 3 to 3⅓ of sand. The mixture should be made under shelter, and in quantities not exceeding from 2 to 3 pints at a time.

Before pointing, the joints should be reamed, and in close masonry they must be open to ⅕ of an inch, then thoroughly saturated with water, and maintained in a condition that they will neither absorb water from the mortar or impart any to it. Masonry should not be allowed to dry rapidly after pointing, but it should be well driven in by the aid of a caulking iron and hammer.

In the pointing of rubble masonry the same general directions are to be observed.

Notes by General Totten, U. S. A.— 240 lbs. lime = 1 cask, will make from 7·8 to 8·15 cubic feet of stiff paste.

308* lbs. of finely-ground cement will make from 3·7 to 3·8 cubic feet of stiff paste; 79 to 83 lbs. of cement powder will make 1 cubic foot of stiff paste.

1 cubic foot of dry cement powder, measured when loose, will measure ·78 to ·8 cubic foot when packed, as at a manufactory.

100 yards of lath and plaster work, with wages of masons at $1.75 per day, and Rockland lime at $1 per cask, cost, respectively: 3 Coats hard finish work, $25.50; 2 Coats slipped work, $19.95.

Mural Efflorescences.— White alkaline efflorescences upon the surface of brick walls laid in mortar, of which natural hydraulic lime or cement is the basis.

The crystallization of these salts within the pores of bricks, into which they have been absorbed from the mortar, causes disintegration.

Ashphalt Flooring.— 8 lbs. of composition will cover 1 sup. foot, $\frac{3}{4}$ inch thick.

Plastering.—1 bushel, or $1\frac{1}{4}$ cubic foot of cement, mortar, etc., will cover $1\frac{1}{2}$ square rods $\frac{3}{4}$ inch thick. 75 volumes are required upon brick work for 70 upon laths.

Cost of Masonry, of various Kinds, per Cubic Yard, and the Volume of Mortar required for each.

Gen. Gillmore, U. S. A.

Mortar.	Volume.	Lime, no Cement used.	Cement, no Lime used.	Difference of Cost with Cement or Lime Mortar.	Cost.	
					Lime Mortar.	Cement Mortar.
	Cu. Ft.	Bbls.	Bbls.	$ Cts.	$ Cts.	$ Cts.
Rough, in rubble or gravel, from $\frac{1}{8}$ to ·1 cubic foot in volume	10·8	·565	1·22	90	4.10	5.
Blocks, large and small, not in courses; joints hammer-dressed	8·1	·423	·92	62	7.	7.63
Large masses; headers and stretchers dovetailed; hammer-dressed; beds and joints laid close	1·	·05	·11	08	9.	9.08
Ordinary; courses 20 to 32 in rise	1·5	·08	·17	12	5.70	
Ordinary; courses 12 to 20 in rise	2·	1·05	·22	16	2.19	
Brick	8·	·42	·9	66	5.70	6.10
Concrete, good	11·	·54	1·75	1.21	2.19	3.20
" medium	9·	·41	1·06	65	1.56	2.21
" inferior	8·	·37	·97	60	1.45	2.05
Rubble, without mortar					3. to	3.30

Cost of materials assumed as follows: Cement, $1.25 per barrel; Lime, $1; Bricks, $4.25 per M; Sand and Gravel, 80 cents per ton; Granite spalls, 55 cents per cubic yard; Labor, $1 per day.

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* 300 lbs. net is the standard barrel, but it usually weighs 308 lbs.

ARTIFICERS' RULES AND TABLES,

For Computing the Work of Bricklayers, Well Diggers, Masons, Carpenters and Joiners, Slaters, Plasterers, Painters, Glaziers, Pavers, and Plumbers.

MEASUREMENT OF BRICKLAYERS' WORK.

Brickwork is estimated at the rate of a number of bricks in thickness, estimating a brick at 4 inches thick. The dimensions of a building are usually taken by measuring half round on the outside, and half round on the inside; the sum of these two gives the compass of the wall, — to be multiplied by the height, for the content of the materials. Chimneys are by some measured as if they were solid, deducting only the vacuity from the hearth to the mantle, on account of the trouble of them. And by others they are girt or measured round for their breadth, and the height of the story is their height, taking the depth of the jambs for their thickness. And in this case, no deduction is made for the vacuity from the floor to the mantle-tree, because of the gathering of the breast and wings, to make room for the hearth in the next story. To measure the chimney shafts, which appear above the building, gird them about with a line for the breadth, to multiply by their height; and account their thickness half a brick more than it really is, in consideration of the plastering and scaffolding. All windows, doors, etc., are to be deducted out of the contents of the walls in which they are placed. But this deduction is made only with regard to materials; for the whole measure is taken for workmanship, and that all outside measure too, namely, measuring quite round the outside of the building, being in consideration of the trouble of the returns or angles. There are also some other allowances, such as double measure for feathered gable ends, etc.

Example.—The end wall of a house is 28 feet long, and 37 feet high to the eaves: 15 feet high is four bricks or 16 inches thick, other 12 feet is three bricks or 12 inches thick, and the remaining 10 feet is two bricks or 8 inches thick; above which is a triangular gable 12 feet high and one brick or 4 inches in thickness. What number of bricks are there in the said wall? *Ans.* 25,620.

Thickness.
28×15=420×4=1680 contents of 1st story.
28×12=336×3=1008 " " 2d "
28×10=280×2= 560 " " 3d "
÷2= 6×28=168×1= 168 " " gable.

3416 square feet area of whole wall.
7½ bricks to square foot.

23,912
1,708

Answer, 25,620 bricks.

By the table.

3000 suprfi. ft. = 22,500 bricks
400 " " = 3,000 "
10 " " = 75 "
6 " " = 45 "

3416 " " = 25,620 bricks

A Table by which to ascertain the Number of Bricks necessary to Construct any piece of Building, from a four-inch Wall to twenty-four inches in thickness.

The utility of the Table can be seen by the following Example. Required the number of bricks to build a wall of 12 inches thickness, and containing an area of 6,437 square feet.

Square feet 1000 22,500 bricks—See table.
× 6 6
6000 = 135,000
400 = 9,000
30 = 675
7 = 158
6,437 = 144,833 bricks.

NOTE.—7½ bricks, equal one superficial foot.

Superficial feet of Wall	Number of Bricks to Thickness of					
	4-inch.	8-inch.	12-inch.	16-inch.	20-inch.	24-inch.
1	8	15	23	30	38	45
2	15	30	45	60	75	90
3	23	45	68	90	113	135
4	30	60	90	120	150	180
5	38	75	113	150	188	225
6	45	90	135	180	225	270
7	53	105	158	210	263	315
8	60	120	180	240	300	360
9	68	135	203	270	338	405
10	75	150	225	300	375	450
20	150	300	450	600	750	900
30	225	450	675	900	1125	1350
40	300	600	900	1200	1500	1800
50	375	750	1125	1500	1875	2250
60	450	900	1350	1800	2250	2700
70	525	1050	1575	2100	2625	3150
80	600	1200	1800	2400	3000	3600
90	675	1350	2025	2700	3375	4050
100	750	1500	2250	3000	3750	4500
200	1500	3000	4500	6000	7500	9000
300	2250	4500	6750	9000	11250	13500
400	3000	6000	9000	12000	15000	18000
500	3750	7500	11250	15000	18750	22500
600	4500	9000	13500	18000	22500	27000
700	5250	10500	15750	21000	26250	31500
800	6000	12000	18000	24000	30000	36000
900	6750	13500	20250	27000	33750	40500
1000	7500	15000	22500	30000	37500	45000

MEASUREMENT OF WELLS AND CISTERNS.

There are two methods of estimating the value of excavating. It may be done by allowing so much a day for every man's work, or so much per cubic foot, or yard, for all that is excavated.

Well Digging.— Suppose a well is 40 feet deep, and 5 feet in diameter, required the number of cubic feet, or yards?

$$5 \times 5 = 25 \times \cdot7851 = 19\cdot635 \times 40 = 785\cdot4 \text{ cubic feet.}$$

Suppose a well to be 4 feet 9 inches diameter, and 16½ feet from the bottom to the surface of the water; how many gallons are therein contained?

$$4\cdot75^2 \times 16\cdot5 \times 5\cdot875 = 2187\cdot152 \text{ gallons.}$$

Again, suppose the well's diameter the same, and its entire depth 35 feet; required the quantity in cubic yards of material excavated in its formation.

$$4\cdot75^2 \times 35 \times \cdot02909 = 22\cdot972 \text{ cubic yards.}$$

A cylindrical piece of lead is required 7½ inches diameter, and 168 lbs. in weight; what must be its length in inches?

$$7\cdot5^2 \times \cdot3223 = 18, \text{ and } 168 \div 18 = 9\cdot3 \text{ inches.}$$

Digging for Foundations, etc.— To find the cubical quantity in a trench, or an excavated area, the length, width and depth must be multiplied together. These are usually given in feet, and therefore, to reduce the amount into cubic yards it must be divided by 27.

Suppose a trench is 40 feet long, 3 feet wide, and 3 feet deep, required the number of cubic feet, or yards?

$$40 \times 3 = 120 \times 3 = 360 \text{ feet} \div 27 = 13\tfrac{1}{3} \text{ yards.}$$

24 cubic feet of sand, 17 ditto clay, 18 ditto earth, equal one ton.

1 cubic yard of earth or gravel, before digging, will occupy about 1½ cubic yards when dug.

MEASUREMENT OF MASONS' WORK.

To masonry belongs all sorts of stone-work; and the measure made use of is a foot, either superficial or solid.

Walls, columns, blocks of stone or marble, etc., are measured by the cubic foot; and pavements, slabs, chimney-pieces, etc., by the superficial or square foot. Cubic or solid measure is used for the materials, and square measure for the workmanship. In the solid measure, the true length, breadth and thickness are taken, and multiplied continually together. In the superficial, there must be taken the length and breadth of every part of the projection, which is seen without the general upright face of the building.

Example.— In a chimney-piece, suppose the length of the mantle and slab each 4 feet 6 inches; breadth of both together 3 feet

2 inches; length of each jamb 4 feet 4 inches; breadth of both together 1 foot 9 inches. Required the superficial content.—*Ans.* 21 feet 10 inches.

$$\left.\begin{array}{l} 4 \text{ ft. } 6 \text{ in.} \times 3 \text{ ft. } 2 \text{ in.} = 14 \text{ ft. } 3 \text{ in.} \\ 4 \text{ " } 4 \text{ " } \times 1 \text{ " } 9 \text{ " } = 7 \text{ " } 7 \text{ " } \end{array}\right\} 21 \text{ feet } 10 \text{ inches.}$$

Rubble Walls (unhewn stone) are commonly measured by the perch, which is 16½ feet long, 1 foot deep, and 1½ foot thick, equivalent to 24¾ cubic feet. 25 cubic feet is sometimes allowed to the perch, in measuring stone before it is laid, and 22 after it is laid in the wall. This species of work is of two kinds, coursed and uncoursed; in the former the stones are gauged and dressed by the hammer, and the masonry laid in horizontal courses, but not necessarily confined to the same height. The uncoursed rubble wall is formed by laying the stones in the wall as they come to hand, without any previous gauging or working.

27 cubic feet of **Mortar** require for its preparation 9 bushels of lime and 1 cubic foot of sand.

Lime and sand lessen about one-third in bulk when made into mortar; likewise cement and sand.

Lime, or cement and sand, to make *mortar*, require as much water as is equal to one-third of their bulk.

All **Sandstones** ought to be placed on their natural beds; from inattention to this circumstance, the stones often split off at the joints, and the position of the lamina much sooner admits of the destructive action of air and water.

The heaviest stones are most suited for docks and harbors, breakwaters to bridges, etc.

Granite is the most durable species of stone yet known for the purposes of building. It varies in weight according to quality; the heaviest is the most durable.

MEASUREMENT OF CARPENTERS' AND JOINERS' WORK.

To this branch belongs all the woodwork of a house, such as flooring, partitioning, roofing, etc. Large and plain articles are usually measured by the square foot or yard, etc., but enriched mouldings, and some other articles, are often estimated by running or lineal measures, and some things are rated by the piece.

All **Joints, Girders,** and in fact all the parts of naked flooring, are measured by the cube, and their quantities are found by multiplying the length by the breadth, and the product by the depth. The same rule applies to the measurement of all the timbers of a roof, and also the framed timbers used in the construction of partitions.

Flooring, that is to say, the boards which cover the naked flooring, is measured by the square. The dimensions are taken from wall to wall, and the product is divided by 100, which gives the number of squares; but deductions must be made for staircases and chimneys.

In measuring of **Joists**, it is to be observed that only one of their dimensions is the same with that of the floor; for the other exceeds the length of the room by the thickness of the wall, and one-third of the same, because each end is let into the wall about two-thirds of its thickness.

No deductions are made for **Hearths** on account of the additional trouble and waste of materials.

Partitions are measured from wall to wall for one dimension, and from floor to floor, as far as they extend, for the other.

No deduction is made for **Doorways** on account of the trouble of framing them.

In measuring of **Joiners' work**, the string is made to ply close to every part of the work over which it passes.

The measure for centring for **Cellars** is found by making a string pass over the surface of the arch for the breadth, and taking the length of the cellar for the length; but in groin centring, it is usual to allow double measure, on account of their extraordinary trouble.

In **Roofing**, the length of the house in the inside, together with two-thirds of the thickness of one gable, is to be considered as the length; and the breadth is equal to double the length of a string which is stretched from the ridge down the rafter, and along the eaves-board, till it meets with the top of the wall.

For **Staircases**, take the breadth of all the steps, by making a line ply close over them, from the top to the bottom, and multiply the length of this line by the length of a step, for the whole area.—By the length of a step is meant the length of the front and the returns at the two ends; and by the breadth, is to be understood the girth of its two outer surfaces, or the tread and riser.

For the **Balustrade**, take the whole length of the upper part of the handrail, and girt over its end till it meets the top of the newel post, for the length; and twice the length of the baluster upon the landing, with the girth of the handrail for the breadth.

For **Wainscoting**, take the compass of the room for the length; and the height from the floor to the ceiling, making the string ply close into all the mouldings, for the breadth. Out of this must be made deductions for windows, doors, chimneys, etc., but workmanship is counted for the whole, on account of the extraordinary trouble.

For **Doors**, it is usual to allow for their thickness, by adding it to both dimensions of length and breadth, and then to multiply them together for the area. If the door be panelled on both sides, take double its measure for the workmanship; but if the one side only be panelled, take the area and its half for the workmanship. For the *surrounding architrave*, gird it about the outermost parts for its length; and measure over it, as far as it can be seen when the door is open, for the breadth.

Window-shutters, bases, etc., are measured in the same manner.

In the measuring of **Roofing** for workmanship alone, holes for chimney-shafts and sky-lights are generally deducted. But in measuring for work and materials, they commonly measure in all sky-lights, lutheran-lights, and holes for the chimney-shafts, on account of their trouble and waste of materials.

The **Doors and Shutters**, being worked on both sides, are reckoned work and half work.

Hemlock and Pine Shingles are generally 18 inches long, and of the average width of 4 inches. When nailed to the roof 6 inches are generally left out to the weather, and 6 shingles are therefore required to a square foot. *Cedar* and *Cypress* Shingles are generally 20 inches long and 6 inches wide, and therefore a less number are required for a "square." On account of waste and defects, 1000 shingles should be allowed to a square.

Two 4-penny **Nails** are allowed to each shingle, equal to 1200 to a square.

The weight of a square of **Partitioning** may be estimated at from 1500 to 2000 lbs.; a square of single-joisted flooring, at from 1200 to 2000 lbs.; a square of framed flooring, at from 2700 to 4500 lbs.; a square of deafening, at about 1500 lbs. 100 superficial feet make one square of boarding, flooring, etc.

In selecting **Timber**, avoid spongy heart, porous grain, and dead knots; choose the brightest in color, and where the strong red grain appears to rise on the surface.

Number of American Iron Machine-Cut Nails in a Pound (by count).

Size.	Number.	Size.	Number.	Size.	Number.
3 penny	408	6 penny	156	12 penny	52
4 "	275	8 "	100	20 "	32
5 "	227	10 "	66	30 "	25

MEASUREMENT OF SLATERS' WORK.

In these articles, the content of a roof is found by multiplying the length of the ridge by the girth over from eaves to eaves; making allowance in this girth for the double row of slates at the bottom, or for how much one row of slates is laid over another. When the roof is of a true pitch, that is, forming a right angle at top, then the breadth of the building, with its half added, is the girth over both sides. In angles formed in a roof, running from the ridge to the eaves, when the angle bends inwards, it is called a valley; but when outwards, it is called a hip. It is not usual to make deductions for chimney-shafts, sky-lights or other openings.

Slates,

[*From the Quarries of Rutland County, Vermont.*]

3 Inch Cover.		2 Inch Cover.	3 Inch Cover.		2 Inch Cover.
Sizes of Slates.	No. of Slates to the Square or 100 Feet.	No. of Slates to the Square or 100 Feet.	Sizes of Slates.	No. of Slates to the Square or 100 Feet.	No. of Slates to the Square or 100 Feet.
24 by 16	86	84	18 by 11	174¼	163½
24 by 14	98	93½	18 by 10	192	180
24 by 12	114	109	18 by 9	213	200
22 by 14	108	102¼	16 by 12	184	171½
22 by 12	126	120	16 by 10	221½	205¾
22 by 10	152	144	16 by 9	246	228½
20 by 14	129	114¼	16 by 8	277	257
20 by 12	143	133⅓	14 by 10	262	240
20 by 11	146	145½	14 by 9	293	266½
20 by 10	169¼	160	14 by 8	327	300
18 by 12	160	150	14 by 7	374	343

"Each Slate is 3 inches BOND OR COVER. The rule for measuring Slating is, to add one foot for all hips and valleys. No deduction is made for Lutheran windows, sky-lights or chimneys, except they are of unusual size; then one-half is deducted."

Imported Slates.

Names of Slates.	Sizes.	Number of Superficial Feet each M of 1200 will cover.	Weight of each M of 1200 Slates.
	Inches. Inches.		
Duchesses	24 by 12	1100	60 cwt.
Marchionesses	22 " 12	1000	55 "
Countesses	20 " 10	750	40 "
Viscountesses	18 " 10	666⅔	36 "
Ladies	16 " 10	583⅓	31 "
"	16 " 8	466⅔	25 "
"	14 " 8	400	22 "
"	12 " 8	333⅓	18½ "
Plantations	14 " 12	600	33 "
"	13 " 10	458⅓	25 "
"	12 " 10	416⅔	23 "
Doubles	13 " 7	320⅚	17½ "
" small	11 " 7	262½	14½ "
School Slates for Blackboards	5 ft. by 2½ ft. 5 feet by 3 ft.		

MEASUREMENT OF PLASTERERS' WORK.

Plasterers' work is of two kinds, namely, ceiling — which is plastering upon laths — and rendering, which is plastering upon walls, which are measured separately.

The contents are estimated either by the foot or yard, or square of 100 feet. Enriched mouldings, etc., are rated by running or lineal measure. One foot extra is allowed for each mitre.

One-half of the openings, windows, doors, etc., allowed to compensate for trouble of finishing returns at top and sides.

Cornices and mouldings, if 12 inches or more in girt, are sometimes estimated by the square foot; if less than 12 inches, they are usually measured by the lineal foot.

1 bushel of cement will cover 1⅐ square yards at 1 inch in thickness.

1 bushel of cement will cover 1½ square yards at ¾ths of an inch in thickness.

1 bushel of cement will cover 2¼ square yards at ½ of an inch in thickness.

1 bushel of cement and 1 of sand will cover 2¼ square yards at 1 inch in thickness.

1 bushel of cement and 1 of sand will cover 3 square yards at ¾ths of an inch in thickness.

1 bushel of cement and 1 of sand will cover 4½ square yards at ½ of an inch in thickness.

1 bushel of cement and 2 of sand will cover 3⅓ square yards at 1 inch in thickness.

1 bushel of cement and 2 of sand will cover 4½ square yards at ¾ths of an inch in thickness.

1 bushel of cement and 2 of sand will cover 6¾ square yards at ½ of an inch in thickness.

1 cwt. of mastic and 1 gallon of oil will cover 1½ yards at ¾, or 2½ at ½ inch.

1 cubic yard of lime, 2 yards of road or drift sand, and 3 bushels of hair, will cover 75 yards of *render and set* on brick, and 70 yards on lath, or 65 yards *plaster*, or *render*, 2 *coats and set* on brick, and 60 yards on lath; floated work will require about the same as 2 coats and set.

Laths are 1¼ to 1½ inches by 4 feet in length, and are usually set ¼th of an inch apart. A bundle contains 100. 1 bundle of laths and 500 nails cover about 4½ yards.

MEASUREMENT OF PAVERS' WORK.

Pavers' work is done by the square yard; and the content is found by multiplying the length by the breadth. Grading for paving is charged by the day.

MEASUREMENT OF GLAZIERS' WORK.

Glaziers' work is sometimes measured by the square foot, sometimes by the piece, or at so much per light; except where the glass is set in metallic frames, when the charge is by the foot. In estimating by the square foot, it is customary to include the whole sash. Circular or oval windows are measured as if they were square.

Table showing the Size and Number of Lights to the 100 Square Feet.

Size.	Lights.	Size.	Lights.	Size.	Lights.	Size.	Lights.
6 by 8	300	12 by 14	86	14 by 22	47	20 by 20	36
7 by 9	229	12 by 15	80	14 by 24	43	20 by 22	33
8 by 10	180	12 by 16	75	15 by 15	64	20 by 24	30
8 by 11	164	12 by 17	71	15 by 16	60	20 by 25	29
8 by 12	150	12 by 18	67	15 by 18	53	20 by 26	28
9 by 10	160	12 by 19	63	15 by 20	48	20 by 28	26
9 by 11	146	12 by 20	60	15 by 21	46	21 by 27	25
9 by 12	133	12 by 21	57	15 by 22	44	22 by 24	27
9 by 13	123	12 by 22	55	15 by 24	40	22 by 26	25
9 by 14	114	12 by 23	52	16 by 16	56	22 by 28	23
9 by 16	100	12 by 24	50	16 by 17	53	24 by 28	21
10 by 10	144	13 by 14	79	16 by 18	50	24 by 30	20
10 by 12	120	13 by 15	74	16 by 20	45	24 by 32	19
10 by 13	111	13 by 16	69	16 by 21	43	25 by 30	19
10 by 14	103	13 by 17	65	16 by 22	41	26 by 36	15
10 by 15	96	13 by 18	61	16 by 24	38	28 by 34	15
10 by 16	90	13 by 19	58	17 by 17	50	30 by 40	12
10 by 17	85	13 by 20	55	17 by 18	47	31 by 36	13
10 by 18	80	13 by 21	53	17 by 20	42	31 by 40	12
11 by 11	119	13 by 22	50	17 by 22	38	31 by 42	12
11 by 12	109	13 by 24	46	17 by 24	35	32 by 42	10
11 by 13	101	14 by 14	73	18 by 18	44	32 by 44	10
11 by 14	94	14 by 15	68	18 by 20	40	33 by 45	10
11 by 15	87	14 by 16	64	18 by 22	36	34 by 46	9
11 by 16	82	14 by 17	60	18 by 24	33	30 by 52	9
11 by 17	77	14 by 18	57	19 by 19	40	32 by 56	8
11 by 18	73	14 by 19	54	19 by 20	38	33 by 56	8
12 by 12	100	14 by 20	51	19 by 22	34	36 by 58	7
12 by 13	92	14 by 21	49	19 by 24	32	38 by 58	7

MEASUREMENT OF PAINTERS' WORK.

Painters' work is computed in square yards. Every part is measured where the color lies; the measuring line is forced into all the mouldings and corners.

Cornices, mouldings, narrow skirtings, reveals to doors and windows, and generally all work not more than nine inches wide, are valued by their length. Sash-frames are charged so much each according to their size, and the squares so much a dozen. Mouldings cut in are charged by the foot run, and the workman always receives an extra price for party-colors. Writing is charged by the inch, and the price given is regulated by the skill and manner in which the work is executed; the same is true of imitations and marbling. The price of painting varies exceedingly, some colors being more expensive and requiring much more labor than others. In measuring open railing, it is customary to take it as flat work, which pays for the extra labor; and as the rails are painted on all sides, the two surfaces are taken. It is customary to allow all edges and sinkings.

MEASUREMENT OF PLUMBERS' WORK.

Plumbers' work is rated at so much a pound, or else by the hundredweight of 112 pounds. Sheet lead, used in roofing, guttering, etc., is from 7 to 12 pounds to the square foot. And a pipe of an inch bore is commonly from 6 to 13 pounds to the yard in length.—[See Table, "*Weight of Lead Pipe per Foot.*"]

SEWERS.

Sewers are classed as Drains, Sewers, and Culverts.

Drains are the small courses, as from one or more locations leading to a sewer.

Sewers are the courses from a series of locations.

Culverts are the courses that receive the discharge of sewers.

The greatest fall of rain is 2 inches per hour = 54308·6 gallons per acre.

Drainage of Lands by Pipes.

Soils.	Depth of Pipes.		Distance apart.	Soils.	Depth of Pipes.		Distance apart.
	Ft.	In.	Feet.		Ft.	In.	Feet.
Coarse gravel sand......	4	6	60	Loam with gravel...	3	3	27
Light sand with gravel	4		50	Sandy loam............	3	9	40
Light loam................	3	6	33	Soft clay.................	2	9	21
Loam with clay..........	3	2	21	Stiff clay................	2	6	15

Sewers.

Circular. $55\sqrt{x \times 2f} = v$, and $v \times a = V$; x *representing area of sewer* $\div$ *the wetted perimeter,* f *inclination of do. per mile, and* v *velocity of flow, in feet per minute;* a *area of flow in square feet, and* V *volume of discharge in cubic feet per minute.*

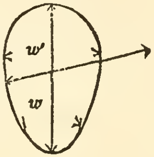
Egg. $\frac{D}{3} = w$, $\frac{2D}{3} = w'$, and $D = r$. D *representing height of sewer,* w *and* w' *width at bottom and top, and* r *radius of sides.*

In culverts less than 6 feet in depth,* the brick-work should be 9 inches thick. When they are above 6 feet and less than 9 feet, it should be 14 inches thick.

If the diameter of top arch = 1, the diameter of inverted arch = ·5, and the total depth = the sum of the two diameters, or 1·5, then the radius of the arcs which are tangential to the top, and inverted, will be 1·5.

From this any two of the elements can be deduced, one being known.

Fig. 42.



Oval. Top and bottom* should be of equal diameters. The diameter ·76 depth of culvert; the intersections of the top and bottom circles form the centres for striking the courses connecting the top and bottom circles.

The inclination of sewers should not be less than 1 foot in 240.

Dimensions, Areas, and Volume of Work per Lineal Foot of Egg-shaped Sewers of different Dimensions.

Internal Dimensions.				Volume of Brick-work.		
Depth.	Diameter of Top Arch.	Diameter of Invert.	Area.	4½ Inch Thick.	9 Inch Thick.	13½ Inch Thick.
Feet.	Feet.	Feet.	Sq. Feet.	Cub. Feet.	Cub. Feet.	Cub. Feet.
2·¼	1·5	·75	2·53	2·81	......	......
3·	2·	1·	4·5	3·56	......	......
3·¾	2·5	1·25	7·03	4·31	9·56	......
4·½	3·	1·5	10·12	5·06	10·87	......
5·½	3·5	1·75	13·78	5·81	12·75	......
6·	4·	2·	18·	6·56	14·25	......
6·¾	4·5	2·25	22·78	7·31	15·75	24·75
7·½	5·	2·5	28·12	......	17·06	27·
8·¼	5·5	2·75	34·03	......	18·	28·41
9·	6·	3·	40·5	......	19·69	30·94

In laying large sewers through quicksands, cast-iron inverts are sometimes employed, and with success, to connect the foundation of the whole work together.

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* Internal dimensions.

Area of Surface from which Circular Sewers will discharge Water equal in Volume to One Inch in Depth upon surface per Hour, including ordinary City Drainage.

Inclination in Feet.	Diameter of Sewers in Feet.					
	2	2½	3	4	5	6
	Area.	Area.	Area.	Area.	Area.	Area.
None.........	$38\frac{3}{4}$	$67\frac{1}{4}$	120	277	570	1020
1 in 480......	48	75	135	308	630	1117
1 in 240......	50	87	155	355	735	1318
1 in 160......	63	113	203	460	950	1692
1 in 120......	78	143	257	590	1200	2180
1 in 80.......	90	165	295	570	1388	2486
1 in 60.......	125	182	318	730	1500	2675

ARCHES AND ABUTMENTS.

Approximate Rules and Tables for the Depth of Arches and Thickness of Abutments.

$C\sqrt{r} = D$. C *representing coefficient, r radius of arch at crown, t thickness of abutment, h height of abutment to spring, and* D *depth of crown in feet.*

In single arches, Stone C = ·3, Brick ·4, and Rubble ·45.

Depths required for the Crowns of Arches.

Radius of Curve.	Stone.	Brick.	Radius of Curve.	Stone.	Brick.	Radius of Curve.	Stone.	Brick.	Radius of Curve.	Stone.	Brick.
Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
2	·42	·56	10	·95	1·26	24	1·47	1·96	80	2·68	3·58
2½	·47	·63	11	1·	1·33	25	1·5	2·	85	2·77	3·69
3	·52	·69	12	1·04	1·38	30	1·64	2·19	90	2·85	3·8
3½	·56	·75	13	1·08	1·44	35	1·78	2·37	95	2·92	3·9
4	·6	·8	14	1·12	1·5	40	1·9	2·53	100	3·	4·
4½	·64	·85	15	1·16	1·55	45	2·01	2·68	110	3·15	4·2
5	·67	·9	16	1·2	1·6	50	2·12	2·83	120	3·29	4·38
5½	·71	·94	17	1·23	1·65	55	2·22	2·97	130	3·42	4·56
6	·74	·98	18	1·27	1·7	60	2·33	3·1	140	3·55	4·73
7	·8	1·06	19	1·31	1·74	65	2·42	3·22	150	3·67	4·9
8	·85	1·13	20	1·34	1·79	70	2·51	3·35	160	3·8	5·06
9	·9	1·2	22	1·41	1·88	75	2·6	3·46	170	4·13	5·22

Minimum Thickness of Abutments for Arches of 120°, where their Depth does not exceed 3 Feet.

Computed from the formula —

$$\sqrt{6r+\left(\frac{3r}{2h}\right)^2}-\frac{3r}{2h}=t.$$

Radius of Arch.	Height of Abutment to Spring in Feet.				
	5	7·5	10	20	30
Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
4·	3·7	4·2	4·3	4·6	4·7
4·5	3·9	4·4	4·6	4·9	5·
5·	4·2	4·9	4·8	5·1	5·2
6·	4·5	4·7	5·2	5·6	5·7
7·	4·7	5·2	5·5	6·	6·1
8·	4·9	5·5	5·8	6·4	6·5
9·	5·1	5·8	6·1	6·7	6·9
10·	5·3	6·	6·4	7·1	7·3
11·	5·5	6·2	6·6	7·3	7·6
12·	5·6	6·4	6·9	7·6	7·9
15·	6·	7·	7·5	8·4	8·8
20·	6·5	7·7	8·4	9·6	10·
25·	6·9	8·2	9·1	10·5	11·1
30·	7·2	9·7	9·7	11·1	12·
35·	7·4	9·1	10·2	11·8	12·9
40·	7·6	9·4	10·6	12·8	13·6
45·	7·8	9·7	11·	13·4	14·3
50·	7·9	10·	11·4	14·	15·

NOTE.— The abutments are assumed to be without counterforts or wing walls.

Keystones.

To Compute the Depth of Keystones for Segmental Arches of Stone.
(TRAUTWINE.)

First Class of Arch. ·36 √ of the radius at the crown.
Second Class of Arch. ·4 √ of the radius at the crown.
Brick or Rubble. ·45 √ of the radius at the crown.
In *Viaducts* of several Arches. Increase the above units to ·42, ·46, and·51.

Railway Bridges.

For Spans between 25 and 70 feet.
Rise, $\frac{1}{5}$ of the Span. *Depth of Arch*, ·055 of the Span.
Thickness of Abutments, from $\frac{1}{4}$ to $\frac{1}{5}$ of the Span. *Batter*, 1 inch per foot.

Cost of Tunnels prior to 1855.—(*Major McClellan, U. S. A.*)

Location.	Per Cubic Yard.
	$ Cts.
Black Rock, U. S., greywacke slate	6 60
Blaisley, France. lined	3 18
Blisworth, Eng., blue clay, lined	1 55
Blue Ridge, U. S.	4 00
England, freestone, marble, clay, etc., lined	3 46
Lehigh, U. S., hard granite	4 36
Schuylkill, U. S., slate	2 00
Union, U. S., slate	2 08

Railway Tunnels.

In soft sandstone, U. S., without lining, per lineal yard...	$88 00
In loose ground, thick lining, per lineal yard.................	710 00
Ordinary brick lining, including centring, per cubic yard.	8 50

Shafts.

Blaisley Tunnel, clay, chalk, and loose earth, per yard in depth, $139.11. Deepest, 646 feet.

Black Rock, 7 feet in diameter and 139 in depth, hard slate, per yard in depth, $79.50, or per cubic yard, $18.72.

The time required to drive the heading of the Black Rock Tunnel for 1782·5 feet was 2387 turns of 12 hours each.

IRON WORKS (ENGLAND).

Temperature of hot blast..	600°
Density of blast and of refining furnace....	2½ to 3 lbs. per sq. in.

Revolutions of puddling rolls per minute, 60; rail rolls, 100; rail saw, 800.

Horse-power (indicated) required for different Processes.

Blast furnace....................	60	Rail rolling train.............	250
Refining furnace...............	26	Small bar train................	60
Puddling rolls with squeezers and shears....................	80	Double rail saw................	12
		Straightening	7

Rolling-Mills.

10 tons bar iron per day......	80	Plates, for each sq. ft. rolled.	5

FLOUR MILLS, SAW MILLS, WOOD-WORKING MACHINERY.

Flour Mills.

For each pair of 4-feet stones, with all the necessary dressing machinery, etc., there is required 15 horses' power.

One pair of 4-feet stones will grind about 5 bushels of wheat per hour. Each bushel of wheat so ground per hour requires ·87 actual or 1·11 indicated horses' power, exclusive of dressing and other machinery.

Stones, 4 feet diameter, 120 to 140 revolutions per minute.

Dressing Machines, 21 inches diameter, 450 to 500 revolutions per minute.

Creepers, 3½ inches pitch, 75 revolutions per minute.

Elevator, 18 inches diameter, 40 revolutions per minute.

Screen, 16 inches diameter, 300 to 350 revolutions per minute.

788 cubic feet of water, discharged at a velocity of 1 foot per second, are necessary to grind and dress 1 bushel of wheat per hour = 1·49 horses' power per bushel.

2000 feet per minute, for the velocity of a stone 4 feet in diameter, may be considered a maximum speed.

Saw-Mills.

Gang saw, 30 square feet of dry oak, or 45 square feet of dry pine, per hour	1 horse-power.
Circular saw, 2·5 feet in diameter, 270 revolutions per minute, 40 square feet of oak, or 70 of dry spruce	1 "

300 revolutions per minute. 1·33 square feet of dry pine per minute, kerf $\frac{7}{32}$ inch and 6 inches deep, requires the power of 1 horse for the saw alone; and 1 square foot, kerf ¼ inch and 1 foot in depth, requires a like power.

4·5 feet in diameter, kerf ¼ and 1 foot in depth, requires 1 horse's power for 1·33 feet per minute.

Oak requires nearly one-half more power than pine.

With a kerf of ⅛ inch, 1 horse's power will saw 2·66 square feet per minute.

The speed of the periphery should be about 50 feet per minute.

Velocities of Wood-working Machinery in Feet or Revolutions per Minute.

Circular saws, at periphery, 6000 to 7000 feet.

Band saw, 2500 feet.

Gang saws, 20 inch stroke, 120 strokes per minute.

Scroll saws, 300 strokes per minute.

Planing-machine cutters at periphery, 4000 to 6000 feet.

Work under planing-machine, $\frac{1}{20}$th of an inch for each cut.

Moulding-machine cutters, 3500 to 4000 feet.

Squaring-up-machine cutters, 7000 to 8000 feet.

Wood-carving drills, 5000 revolutions.

Machine augers, 1½ diameter, 900 revolutions.

Machine augers, ¾ diameter, 1200 revolutions.

Gang saws require for 45 superficial feet of pine per hour, 1 horse power.

Circular saws require for 75 superficial feet of pine per hour, 1 horse power.

In oak or hard wood, ¾ths of the above quantity require 1 horse power.

Sharpening Angles of Machine Cutters.

Adzing soft wood across the grain	30°
Planing-machines, ordinary soft wood	35°
Gouges and ploughing machines	40°
Hard-wood tool cutters	50° to 55°

MINING AND BLASTING.

Mining.

In ordinary Soil, $\frac{l^3}{10}$ = *charge of powder in pounds, l representing half the depth of the line of least resistance.*

In Masonry, $l^3 \times C$ = *charge in pounds; C representing a coefficient depending upon the structure.*

In a plain Wall, C = ·15, in one with counterforts = ·2, and under a foundation when it is supported upon two sides = ·4 to ·6.

Blasting.

In small blasts, 1 pound of powder will loosen about 4½ tons.

In large blasts, 1 pound of powder will loosen about 2¾ tons.

50 or 60 pounds of powder, enclosed in a resisting bag, hung or propped up against a gate or barrier, will demolish any ordinary construction.

One man can bore, with a bit 1 inch in diameter, from 50 to 100 inches per day of 10 hours in granite, or 300 to 400 inches per day in limestone.

Two strikers and a holder can bore, with a bit 2 inches in diameter, 10 feet in a day in rock of medium hardness.

PROJECTION OF WATER.

Heights to which Water may be Projected through Engine Pipes under Pressure.

Pressure per Sq. Inch.	Equivalent Head of Water.	Height of Jet.	Ratio of Compression of Air in Air-chamber.	Pressure per Sq. Inch.	Equivalent Head of Water.	Height of Jet.	Ratio of Compression of Air in Air-chamber.
Lbs.	Feet.	Feet.		Lbs.	Feet.	Feet.	
30	68	33	·5	90	204	165	·17
45	102	66	·33	105	238	198	·14
60	136	99	·25	120	272	231	·125
75	170	132	·2	150	340	297	·1

Power required to raise Water from Wells by a Double-acting Lifting Pump.

Diameter of Pump.	Volume per Hour.	Depth from which this Volume can be raised by each Unit of Power.			
		Man turning a Crank.	Donkey working a Gin.	Horse working a Gin.	One Horse-power Engine.
Inches.	Gallons.	Feet.	Feet.	Feet.	Feet.
2	265	80	160	560	880
$2\frac{1}{2}$	420	50	100	350	550
3	620	35	70	245	385
$3\frac{1}{2}$	830	25	50	175	275
4	1060	20	40	140	220

WATER-POWER.

To Compute Water-power.

$\cdot 00189\,V h =$ *horse's power, and* $\frac{528\,HP}{V} = V$; V *representing volume of water, in cubic feet, per minute, and h head of water from race in feet.*

Effective Horse-power for different Motors.

Theoretical power.. 1·

Undershot wheels......... = ·4
Poncelet's un'shot wheel = ·6
Breast wheel (high)...... = ·55
" (low)....... = ·6
Overshot wheel............ $= \left\{ \begin{array}{l} \cdot 84 \\ \cdot 64 \end{array} \right.$

Reaction wheel........... = ·2
Impact wheel .... = ·5
Turbines..................... $= \left\{ \begin{array}{l} \cdot 6 \\ \cdot 75 \end{array} \right.$
Tremont turbine.......... = ·79
Hydraulic ram .... = ·6

Hydraulic Ram.

$\frac{882\,HP}{h} = V$, $\cdot 00113\,V h = HP$; V *representing volume of water in cubic feet per minute, h head of water in feet, and* HP *actual horse-power.*

Jet Pump.

The greatest effect of a Jet Pump is when the depth from which the water is drawn through the supply or suction pipe is ·9 of the height from which the water fell to give the jet.

The flow up the suction pipe being ·2 of that of the volume of the jet; hence the effect = ·9 × ·2 = ·18.

Imperial Gallons.

6·2355 Gallons in a Cubic Foot.

WAVES.

The undulations of waves are performed in the same time as the oscillations of a pendulum, the length of which is equal to the breadth of a wave, or to the distance between two neighboring cavities or eminences.

SOLDERS.

	Copper.	Tin.	Lead.	Zinc.	Silver.	Bismuth.	Gold.	Calcimine	Antimony
Tin	......	25	75	......	......	......	......	......	......
"	......	58	16	......	......	16	......	......	10
" coarse, melts at 500°	......	33	67	......	......	......	......	......	......
" ordinary, melts at 360°	......	67	33	......	......	......	......	......	......
Spelter, soft	50	......	......	50	......	......	......	......	......
" hard	67	......	......	33	......	......	......	......	......
Lead	......	33	67	......	......	......	......	......	......
Steel	13	......	......	5	82	......	......	......	......
Brass or Copper	50	......	......	50	......	......	......	......	......
Fine Brass	47	......	......	47	6	......	......	......	......
Pewterers' or Soft	......	33	45	......	......	22	......	......	......
" "	......	50	25	......	......	25	......	......	......
Gold	4	......	......	......	7	......	89	......	......
" hard	66	......	......	34	......	......	......	......	......
" soft	......	66	34	......	......	......	......	......	......
Silver, hard	20	......	......	......	80	......	......	......	......
" soft	12	......	......	......	67	......	......	21	......
Pewter	......	40	20	......	......	40	......	......	......
Iron	66	......	......	33	......	......	......	......	1
Copper	53	47	......	......	......	......	......	......	......

A PLASTIC METALLIC ALLOY.—See Journal of Franklin Institute, vol. xxxix, page 55, for its composition and manufacture.

Composition for Welding Cast Steel.—Borax, 10 parts; sal-ammoniac, 1 part. Grind or pound them roughly together; fuse them in a metal pot over a clear fire, continuing the heat until all spume has disappeared from the surface. When the liquid is clear, pour the composition out to cool and concrete, and grind to a fine powder; then it is ready for use.

To use this composition, the steel to be welded should be raised to a bright yellow heat; then dip it in the welding powder, and again raise it to a like heat as before; it is then ready to be submitted to the hammer.

FUSIBLE COMPOUNDS.

Compounds.	Zinc.	Tin.	Lead.	Bismuth.	Cadmium.
Rose's fusing at 200°	....	25	25	50	....
Fusing at less than 200°	33.3	....	33.3	33.4	....
Newton's, fusing at less than 212°	....	19	31	50	....
Fusing at 150° to 160°	....	12	25	50	13

Soldering Fluid for use with Soft Solder.—To 2 fluid oz. of muriatic acid add small pieces of zinc until bubbles cease to rise. Add ½ a teaspoonful of sal-ammoniac and 2 fluid oz. of water.

By the application of this to iron or steel, they may be soldered without their surfaces being previously tinned.

FLUXES FOR SOLDERING OR WELDING.

Iron	Borax.
Tinned Iron	Resin.
Copper and Brass	Sal-ammoniac.
Zinc	Chloride of zinc.
Lead	Tallow of resin.
Lead and tin pipes	Resin and sweet oil.

STEEL.—Sal-ammoniac, 1 part; borax, 10 parts. Pound together, and fuse until clear, and, when cool, reduce to powder.

Babbitt's Anti-attrition Metal.—Melt 4 lbs. copper; add, by degrees, 12 lbs. best Banca tin; 8 lbs. regulus of antimony, and 12 lbs. more of tin. After 4 or 5 lbs. tin have been added, reduce the heat to a dull red, then add the remainder of the metal as above.

This composition is termed *hardening;* for lining, take 1 lb. of this *hardening*, melt with it 2 lbs. Banca tin, which produces the lining metal for use. Hence, the proportions for lining metal are 4 lbs. of copper, 8 of regulus of antimony, and 96 of tin.

MISCELLANEOUS NOTES.

DIMENSIONS OF DRAWINGS FOR PATENTS.— United States, all of drawing and signature to be within marginal line of 8 x 13 inches. Leave 1 inch margin, making the paper 10 x 15 inches.

SERVICE TRAIN OF A QUARTERMASTER.—The Quartermaster's train of an army averages 1 wagon to every 24 men; and a well-equipped army in the field, with artillery, cavalry, and trains, requires 1 horse or mule, upon the average, to every 2 men.

A LUMINOUS POINT, to produce a *visual* circle, must have a velocity of 10 feet in a second, the diameter not exceeding 15 inches.

All solid bodies become *luminous* at 800 degrees of heat.

TIDES.—The difference in time between high water averages about 49 minutes each day.

In sandy soil, the greatest force of a pile-driver will not drive a pile over 15 feet.

A FALL of .1 of an inch in a mile will produce a *current* in rivers.

MELTED SNOW produces from ¼ to ⅛ of its bulk in water.

At the depth of 45 feet, the *temperature of the earth* is uniform throughout the year.

A SPERMACETI CANDLE .85 of an inch in diameter consumes an inch in length in 1 hour.

SILICA is the base of the mineral world, and *Carbon* of the organized.

SOUND passes in water at a velocity of 4,708 feet per second.

METALS have five degrees of lustre—*splendent, shining, glistening, glimmering* and *dull.*

A MARBLE-SAW requires half a horse's power.

WIRE AND HEMP ROPES.—A wire rope 3½ ins. in circumference, and a hemp shroud 8 ins. in circumference, parted in the rope at 10½ tons—4,600 lbs. per square inch.

ENDLESS ROPES.—The friction or adhesion of ropes is from .1 to .07 of their weight.

Brief Rules for the Computation of the Weights of Cast Iron Pipes and Cast and Wrought Iron Bolts.--(Horatio Allen.) —CAST IRON PIPES.—To the inner diameter of the pipe add the thickness of the pipe in inches, and multiply the sum by 10 times the thickness, and the product will give the weight in pounds per foot.

WROUGHT IRON BOLTS.—Square the radius of the bolt and multiply it by 10, and the product will give the weight in pounds per foot.

For cast iron, subtract 2-27, or, .074 of the result.

MALLEABLE OR ALUMINUM BRONZE.—By weight: Copper, 90; Aluminum, 10. This composition may be forged either when heated or cooled, and becomes extremely dense. Its tensile strength is 100,000 lbs., and when drawn into wire 128,000 lbs., and its elasticity one half that of wrought iron. Specific gravity, 7700.

STRENGTH OF MATERIALS.

ELASTICITY AND STRENGTH.

The component parts of a rigid body adhere to each other with a force which is termed *cohesion.*

Elasticity is the resistance which a body opposes to a change of form.

Strength is the resistance which a body opposes to a permanent separation of its parts.

Elasticity and *strength*, according to the manner in which a force is exerted upon a body, are distinguished as *tensile strength*, or absolute resistance; *transverse strength*, or resistance to flexure; *crushing strength*, or resistance to compression; *torsional strength*, or resistance to torsion; and *detrusive strength*; or resistance to shearing.

The *limit of stiffness* is flexure, and the limit of strength or resistance is fracture.

Resilience, or toughness of bodies, is strength and flexibility combined; hence any material or body which bears the greatest load, and bends the most at the time of fracture, is the toughest.

The *specific gravity* of iron is ascertained to indicate very correctly the relative degree of its strength.

The *neutral axis*, or *line of equilibrium*, is the line at which extension terminates and compression begins.

The *resistance* of cast iron to crushing and tensile strains is, as a mean, as 4, 3 to 1.*

English cast iron has a higher resistance to compression, and a less tensile resistance, than American.

The *mean tensile strength* of American cast iron, as determined by Major Wade for the U. S. Ordnance Corps, is 31,829 lbs. per square inch of section; the mean of English, as determined by Mr. E. Hodgkinson for the Railway Commission, etc., in 1849, is 19,484 lbs.; and by Col. Wilmot at Woolwich, in 1858, for gun-metal, is 23,257 lbs

The *ultimate extension* of cast iron is the 500th part of its length.

The *mean traverse strength* of American cast iron, also determined by Major Wade, is 681-lbs. per square inch, suspended from a bar fixed at one end and loaded at the other; and the mean of English, as determined by Fairbairn, Barlow, and others, is 500 lbs.

The *resistance of wrought iron* to crushing and tensile strains is, as a mean, as 1·5 to 1 for American; and for English, 1·2 to 1.

The *mean tensile strength* of American wrought iron, as determined by Prof. Johnson, is 55,900 lbs., and the mean of English, as determined by Capt. Brown, Barlow, Brunel, and Fairbairn, is 53,900 lbs.†

The *ultimate extension* of wrought iron is the 600th part of its length.

The *resistance to flexure*, acting evenly over the surface, is nearly ½ the tensile resistance.

Modulus of Elasticity.—The *modulus* or *coefficient of the elasticity* of any substance is the measure of its elastic reaction or force, and is the height of a column of the same substance, capable of producing a pressure on its base, which is to the weight causing a certain degree of compression, as the length of the substance is to the diminution of its length.

It is computed by this analogy: As the extension or diminution of the length of any given substance is to its length in inches, so is the force that produced that extension or diminution to the modulus of its elasticity.

Or, $x : P :: l : w = \frac{P}{x}$, x representing the length a substance 1 in square and 1 foot in length would be extended or diminished by the force P, and w the weight of the modulus in lbs.

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*The experiments of Mr. Hodgkinson on iron of low tensile strength gives a mean of 6.595 to 1.

†The results, as given by Mr. Telford, included experiments upon Swedish iron; hence they are omitted in this summary.

To Compute the Weight of the Modulus of Elasticity of a Substance.—RULE.—As the extension or compression of the length of any substance is to its length, so is the weight that produced that extension or compression to the modulus of elasticity in pounds avoirdupois.

EXAMPLE.—If a bar of cast-iron, 1 inch square and 10 feet in length, is extended .008 inch, with a weight of 1000 lbs., what is the weight of its modulus of elasticity?

$$.008 : 120\ (10 \times 12) :: 1000 : 15{,}000{,}000 \text{ lbs.}$$

NOTE.—When the weight of the modulus of elasticity of a substance is known, the height of it can be readily computed by dividing the weight by the weight of a bar of the substance 1 inch square and 1 foot in length.

EX. 2.—If a wrought-iron chain, 60 feet in length and .2 inch in diameter, is subjected to a strain of 150 lbs., what will it be extended?

The modulus of elasticity of iron wire is 26,808,000 lbs., and the area of chain $.2^2 \times .7854 = .31416$.

$$\frac{150}{.31416} = 477{,}463 \text{ lbs. per square inch, and } 60 \times 12 = 720 \text{ ins.}$$

$$\text{Then } 477{,}463 \times \frac{120}{26{,}808{,}000} = \frac{343{,}773\ 36}{26{,}808{,}000} = .0128 \text{ inch.}$$

To Compute the Weight when the Height is Given.—RULE.—Multiply the weight of 1 foot in length of the material by the height of the modulus in feet, and the product will give the weight.

To Compute the Height of the Modulus of Elasticity.—RULE.—Divide the weight of the modulus of elasticity of the material by weight of 1 foot of it and the quotient will give the height in feet.

From a series of elaborate experiments by Mr. E. Hodgkinson for the Railway Commission, he deduced the following formulæ for the extension and compression of cast and wrought iron:

CAST-IRON EXTENSION: $13{,}934{,}040 \frac{e}{l} - 2{,}907{,}432{,}000 \frac{e^2}{l^2} = W$.

CAST-IRON COMPRESSION: $12{,}931{,}560 \frac{c}{l} - 522{,}979{,}200 \frac{c^2}{l^2} = W$, e and c representing the extension and compression, and l the length in inches.

ILLUSTRATION.—What weight will extend a bar of cast-iron, 4 inches square and 10 feet in length, to the extent of .2 inch?

$$13{,}934{,}040 \times \frac{.2}{120} - 2{,}907{,}432{,}000 \frac{.2^2}{120^2} = 23223.4 - 8076.2 = 15147.2, \text{ which} \times 4 \text{ ins.} = 60588.8 \text{ lbs.}$$

MODULUS OF ELASTICITY AND WEIGHT OF VARIOUS SUBSTANCES.

SUBSTANCES.	Height in feet.	Weight in lbs.	SUBSTANCES.	Height in feet.	Weight in lbs.
Ash	4,970,000	1,656,670	Lignum-vitæ	1,850,000	1,080,400
Brass, yellow	2,460.000	8,464,000	Limestone	2,400,000	3,300,000
" wire	4 112,000	14,632,720	Mahogany	6,570,000	2,071.000
Copper, cast	4,800,000	18,240.000	Marble, white	2,150,000	2,508,000
Elm	5,680,000	1,499,500	Oak	4,750 000	1,710,000
Fir, red	8,330,000	2,016,000	Pine, Pitch,	8,700,000	2,430,000
Glass	4,440,000	5,550,000	" White	8,900.000	1,830,000
Gun-metal	2,790,000	8,844,300	Steel, cast	8,530,000	26,650,000
Hempen fibres.	5.000,000	170,000	" wire	9,000,090	28,689.000
Ice	6,000,000	2,370,000	Stone, Portland	1,672,000	1,718.800
Iron, cast	5,750.900	1,796,850	Tin, cast	1,053,000	3,510,000
" wrought	7,550.000	25.820.000	Willow	6.200 000	1,426,000
" wire	8,377,000	28,230.500	Yel. Pine, mean	10.500,000	2,100,000
Lead, cast	146,000	720,000	Zinc	4,480,000	13,440,000

The elasticity of Ivory, as compared to Glass, is as .95 to 1.

To Compute the Length of a Prism of a Material which would be severed by its own Weight when Suspended.—RULE.—Divide the tensile resistance of the material by the weight of a foot of it in length, and the quotient will give the length.

Modulus of Cohesion, or Length in Feet required to Tear assunder the following Substances.—Rawhide, 15,375 feet; hemp twine, 75,000 feet; Catgut, 25,000 feet.

Tensile Strength.—*Tensile strength* is the resistance of the fibres or particles of a body to separation. It is therefore proportional to their number, or to the area of its transverse section.

The *fibres of wood* are strongest near the centre of the trunk or limb of a tree.

CAST IRON.—Experiments on cast iron bars give a tensile strength of from 4,000 lbs. to 5,000 lbs. per square inch of its section, as just sufficient to balance the elasticity of the metal, and as a bar of it is extended the 5500th part of its length for every ton of direct strain per square inch of its section, it is deduced that its elasticity is fully excited when it is extended less than the 3000th part of its length, and the extension of it at its limit of elasticiy is estimated at the 1200th part of its length.

The *mean tensile strength*, then, of cast iron being from 16,000 to 20,000 lbs., the *value* of it, when subjected to a tensile strain, may be safely estimated at from ¼ to ⅓ of this, or of its breaking strain.

A bar of cast iron will *contract or expand* .000006173, or the 162000th of its length for each degree of heat; and assuming the extreme range of the temperature in this country 140° (—20° + 120°), it will contract or expand with this change .0008642, or the 1157th part of its length. It shrinks in cooling from .0104 to .0118 of its length.

It follows, then, that as 2240 lbs. will extend a bar the 5500th part of its length, the contraction or extension for the 1157th part will be equivalent to a force of 10,648 lbs. (4¾ tons) per square inch of section.

Cast iron (Greenwood) at three successive meltings gave tenacities of 21,300, 30,100, and 35,700 lbs.

Cast iron at 2.5 tons per square inch will extend the same as wrought iron at 5.6 tons.

The *mean tensile strength* of four kinds of English cast iron, as determined by the Commissioners on the Application of Iron to Railway Structures, was 15,711 lbs. per square inch (7.014 tons); and the mean ultimate extension was, for lengths of 10 feet, .1997 inch, being the 600th part of its length; and this weight would compress a bar the 775th part of its length.

Tensile strength of the strongest piece of cast iron ever tested—45,970 lbs. This was a mixture of grades 1, 2, and 3 of Greenwood iron, and at the 3d fusion.

WROUGHT IRON. — Experiments on wrought iron bars give a *tensile strength* of from 18,000 lbs. to 22,400 lbs. per square inch of its section, as just sufficient to balance the elasticity of the metal, and as a bar of it is extended the 10,000th part of its length for every ton of direct strain per square inch of its section, it is deduced that its elasticity is fully excited when it is extended the 1000th part of its length, and the extension of it at its limit of elasticity is estimated at the 1520th part of its length.

The *mean tensile strength* of wrought iron being from 55,000 to 65,000 lbs., the *value* of it, when subjected to a tensile strain, may be safely estimated at from ¼ to ⅓ of this, or of its breaking strain. A bar of wrought iron will *expand or contract* .000006614, or the 151,200th part of its length for each degree of heat; and assuming, as before stated for cast iron, that the extreme range of temperature in the air in this country is 140°, it will contract or expand with this change .000926, or the 1080th of its length, which is equivalent to a force of 20,740 lbs. (9¼ tons) per square inch of section.

Experiments upon wrought iron, to determine the results from repeated heating and laminating, furnished the following:—From 1 to 6 reheating and rollings, the *tensile strength* increased from 43,904 lbs. to 61,824 lbs., and from 6 to 12 it was reduced to 43,904 again.

The *tensile force* of metals varies with their temperature, generally decreasing as the temperature is increased. In silver the tenacity decreases more rapidly than the temperature; in copper, gold, and platinum it decreases less rapidly than the temperature.

In iron, the *tensile strength* at different temperature is as follows: 60°, 1; 114°, 1.14; 212°, 1.2; 250°, 1.32; 270°, 1.35; 325°, 1.41; 435°, 1.4.

STIRLING'S MIXED OR TOUGHENED IRON.—By the mixture of a portion of malleable iron with cast iron, carefully fused in a crucible, a tensile strain of 25,764 lbs. has been attained. This mixture, when judiciously managed and duly proportioned, increases the resistance of cast iron about one-third; the greatest effect being obtained with a proportion of about 30 per cent. of malleable iron.

Bronze (gun-metal) varies in *tenacity* from 23,000 to 54,500 lbs.

ELEMENTS CONNECTED WITH THE TENSILE RESISTANCE OF VARIOUS SUBSTANCES.

SUBSTANCES.	Tensile Strain per Sq. Inch for limit of Elasticity.	Ratio of Strain to that causing Rupture.	SUBSTANCES.	Tensile Strain per Sq. Inch for limit of Elasticity.	Ratio of Strain to that causing Rupture.
	Lbs.			Lbs.	
Beech	3,355	.3	Wrought-iron, Swe.	24,400	.34
Cast-iron, English	4,000	.22	" Eng.	18,850	.35
" American	5,000	.2		22,400	.35
Oak	2,856	.23	" Am.	21,000	.26
Steel plates, blue tempered	93,720	.62	Wrought wire, No. 9, unannealed	47,532	.49
Steel wire	35,700	.5	Wrought wire, No. 9, annealed	36,300	.45
Yellow Pine	3,332	.23			
Wrought-iron, or'dy	17,600	.3			

TENSILE STRENGTH OF MATERIALS.

WEIGHT OR POWER REQUIRED TO TEAR ASUNDER ONE SQUARE INCH.

METALS.

	Lbs.		Lbs.
Copper, wrought	34000	Iron plates, mean, English	51000
" rolled	36000	" " lengthwise	53800
" cast, American	24250	" " crosswise	48800
" wire	61200	" inferior, bar	30000
" bolt	36800	" wire, American	73600
Iron, cast, Low Moor, No. 2	14076	" " " 16 diam	80000
" Clyde, No. 1	16125	" scrap	53400
" " No. 3	23468	Lead, cast	1800
" Calder, No. 1	13735	" milled	3320
" Stirling, mean	25764	" wire	2580
" mean of American	31829	Platinum, wire	53000
" mean* of English	19484	Silver, cast	40000
" Greenwood, Amer'n	45970	Steel, cast, maximum	142000
" gun-metal, mean	37,232	" " mean	88657
" wrought wire	103000	" blistered, soft	133000
" best Swedish bar	72000		104000
" Russian bar	59500	" shear	124000
" English bar	56000	" chrome, mean	170980
" rivets, American	53300	" puddled, extreme	173817
" bolts	52250	" American Tool Co	179980
" hammered	53913	" plates, lengthwise	96300
" mean of English	53900	" " crosswise	93700
" rivets, English	65000	" razor	150000
" crank shaft	44750	Tin, cast, block	5000
" turnings	55800	" Banca	2122
" plates, boiler, American	48000	Zinc	3500
	62000	" sheet	16000

Lake Superior and Iron Mountain charcoal bloom iron has resisted 90000 lbs. per square inch.

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* By Commissioners on Application of Iron to Railway Structures.

MISCELLANEOUS SUBSTANCES.

	Lbs.		Lbs.
Brick, well burned	750	Limestone	670
" fire	65		2800
" inferior	290	Marble, Italian	5200
	100	" white	9000
Cement, blue stone	77	Mortar, 12 years old	60
" hydraulic	234	Plaster of Paris	72
" Harwich	30	Rope, Manilla	9000
" Portland, 6 mos.	414	" hemp, tarred	15000
" Sheppy	24	" wire	37000
" Portland 1, sand 3	380	Sandstone, fine grain	200
Chalk	118	Slate	12000
Glass, crown	2346	Stone, bath	352
Gutta-percha	3500	" Craigleth	400
Hydraulic lime	140	" Hailes	360
" " mortar	140	" Portland	857
Ivory	16000		1000
Leather belts	330	Whalebone	7600

COMPOSITIONS.

	Lbs.		Lbs.
Gold 5, Copper 1	50000	Copper 10, Tin 1	32000
Brass	42000	" 8, Tin 1, gun-metal	30000
" yellow	18000	" 8, " 1, small bars	50000
Bronze, least	17698	Tin 10, Antimony 1	11000
" greatest	56788	Yellow metal	48700

WOODS.

	Lbs.		Lbs.
Ash	14000	Maple	10500
Beech	11500	Oak, American white	11500
Box	20000	" English	10000
Bay	15000	" seasoned	13600
Cedar	11400	" African	14500
Chestnut, sweet	10500	Pear	9800
Cypress	6000	Pine, pitch	12000
Deal, Christiana	12400	" larch	9500
Elm	13400	" American white	11800
Lance	23000	Poplar	7000
Lignum-vitæ	11800	Spruce, white	10290
Locust	20500	Sycamore	13000
Mahogany	21000	Teak	14000
" Spanish	12000	Walnut	7800
" "	8000	Willow	13000

RESULTS OF EXPERIMENTS ON THE TENSILE STRENGTH OF WROUGHT IRON TIE RODS.

Common English Iron, $1\frac{3}{16}$ Inches in Diameter.

Description of Connection.	Breaking Weight.
	Lbs.
Semicircular hook fitted to a circular and welded eye..........	14000
Two semicircular hooks hooked together..............................	16220
Right-angled hook or goose-neck fitted into a cylindrical eye	29120
Two links or welded eyes connected together.........................	48160
Straight rod without any connection articulation................	56000

Iron bars when cold rolled are materially stronger than when only hot rolled, the difference being in some cases as great as 3 to 2.

WIRE ROPES.

RESULT OF EXPERIMENTS ON THE TENSILE STRENGTH OF IRON AND STEEL WIRE ROPES.

Charcoal Iron Wire Rope. Circum.	Weight per foot.	Breaking Weight	Steel Wire Rope. Circum.	Stretch in 6 feet.	Weight per foot.	Breaking Weight.
Ins.	Lbs.	Lbs.	Ins.	Ins.	Lbs.	Lbs.
$1\frac{7}{8}$	$\frac{1}{2}$	13440	$1\frac{15}{16}$	$1\frac{3}{8}$	$\frac{1}{2}$	33600
$3\frac{3}{8}$	$1\frac{1}{2}$	44800	$2\frac{3}{8}$	$\frac{5}{8}$	$\frac{7}{8}$	56000

EXTENSION OF CAST-IRON BARS WHEN SUSPENDED VERTICALLY.

1 Inch Square and 10 Feet in Length. Weight applied at one end.

Weight applied.	Extension.	Set.	Weight applied.	Extension.	Set.
Lbs.	Ins.	Ins.	Lbs.	Ins.	Ins.
529	.0044	....	4234	.0397	.00265
1058	.0092	.000015	8468	.0871	.00855
2117	.0190	.000059	14820	.1829	.02555

Steel.—The tensile strength of steel increases by reheating and rolling up to the second operation, but decreases after that.

The relative resistance of wrought iron and copper to tension and compression is as 100 to 54.5.

Transverse Strength.—*The Transverse or Lateral Strength of any Bar, Beam, Rod, etc.*, is in proportion to the product of its breadth and the square of its depth; in like-sided beams, bars, etc., it is as the cube of the diameter of the section.

When one end is fixed and the other projecting, the strength is inversely as the distance of the weight from the section acted upon; and the strain upon any section is directly as the distance of the weight from that section.

When both ends are supported only, the strength is 4 times greater for an equal length, when the weight is applied in the middle between the supports, than if one end only is fixed.

When both ends are fixed, the strength is 6 times greater for an equal length, when the weight is applied in the middle, than if one end only is fixed.

The strength of any beam, bar, etc., to support a weight in the centre of it, *when the end rests merely upon two supports*, compared to one *when the ends are fixed*, is as 2 to 3.

When the weight or strain is uniformly distributed, the weight or strain that can be supported, compared with that when the weight or strain is applied at one end or in the middle between the supports, is as 2 to 1.

In metals, the less the dimension of the side of a beam, etc., or the diameter of a cylinder, the greater its proportionate transverse strength. This is in consequence of their having a greater proportion of chilled or hammered surface compared to their elements of strength, resulting from dimensions alone.

The strength of a *cylinder*, compared to a *square* of like diameter or sides, is as 6.25 to 8. The strength of a *hollow cylinder* to that of a *solid cylinder*, of the same length and volume, is as the greater diameter of the former is to the diameter of the latter.

The strength of an *equilateral triangle, fixed at one end and loaded at the other*, having an *edge up*, compared to a *square* of the same area, is as 22 to 27; and the strength of an equilateral triangle, having an *edge down*, compared to one with an *edge up*, is as 10 to 7.

NOTE.—In these comparisons, the beam, bar, etc., is considered as one end being *fixed*, the weight suspended from the other. In Barlow and other authors the comparison is made when the beam, etc., rested upon *supports*. Hence the stress is contrariwise.

Detrusion is the resistance that the particles or fibres of materials oppose to their sliding upon each other. Punching and shearing are detrusive strains.

Deflection.—When a bar, beam etc., is deflected by a cross-strain, the side of the beam, etc., which is bounded by the concave surface, is *compressed*, and the opposite side is *extended.*

In *stones and cast metals*, the resistance to *compression* is greater than the resistance to extension.

In *woods*, the resistance to *extension* is greater than the resistance to compression.

The general law regarding *deflection* is, that it increases, *cœteris paribus*, directly as the cube of the length of the beam, bar, etc., and inversely as the breadth and cube of the depth.

The resistance of *flexure* of a body at its cross-section is very nearly 9-10 of its tensile resistance.

The *stiffest bar or beam* that can be cut out of a cylinder is that of which the depth is to the breadth as the square root of 3 to 1; the *strongest*, as the square root of 2 to 1; and the most *resilient*, that which has the breadth and depth equal.

RELATIVE STIFFNESS OF MATERIALS TO RESIST A TRANSVERSE STRAIN.

Ash	.089	White pine	.1
Beech	.073	Yellow pine	.087
Elm	.079	Wrought iron	1.3
Oak	.095	Cast iron	1.

The strength of a rectangular beam in an *inclined position*, to resist a vertical stress, is to its strength in a horizontal position as the square of radius to the square of the cosine of elevation; that is, as the square of the length of the beam to the square of the distance between its points of support, measured upon a horizontal plane.

Experiments upon bars of cast iron, 1, 2, and 3 inches square, give a result of transverse strength of 447, 348, and 338 lbs. respectively; being in the ratio of 1, .78, and .756.

The *strongest rectangular bar or beam* that can be cut out of a cylinder is one of which the squares of the breadth and depth of it, and the diameter of the cylinder, are as 1, 2, and 3 respectively.

The ratio of the *crushing* to the *transverse* strength is nearly the same in glass, stone, and marble, including the hardest and softest kinds.

Green sand iron castings are 6 per cent. stronger than dry, and 30 per cent. stronger than chilled; but when the castings are chilled and annealed, a gain of 115 per cent. is attained over those made in green sand.

Chilling the under side of cast iron very materially increases its strength.

WOODS.—*Beams of wood*, when laid with their annual or annular layers vertical, are stronger than when they are laid horizontal, in the proportion of 8 to 7.

Woods are *denser at the roots* and at the centre of their trunks. Their strength decreases with the decrease of their density.

TRANSVERSE STRENGTH OF MATERIALS, DEDUCED FROM EXPERIMENTS.

Reduced to the uniform Measure of One Inch Square, and one Foot in Length; Weight suspended from one End.

MATERIALS.	Breaking weight.	Value for general use.
METALS.	Lbs	
Cast iron, American, means of four divisions of grades	507	125 to 160
	622	155 " 210
	733	180 " 240
	772	192 " 250
" mean by Maj. Wade	681	170 " 225
" West Pt. Foundry, extreme	980	250 " 325
" English, Low Moor, cold blast	472	110 " 140
" Ponkey, cold	581	145 " 190
" hot blast, mean	500	125 " 165
" cold " "	516	130 " 170
" Ystalyfera, cold bl't	770	195 " 255
" mean of 65 kinds	500	125 " 165
" mean of 15 kinds, direct from the Pig, cold blast	641	160 " 215
" planed bar	518	130 " 170
" rough bar	534	133 " 175
Steel, greatest	1918	350 " 450
Steel, puddled (permanent bend)	800	170 " 225
WOODS.		
Ash	168	55
Beech	130	32
Birch	160	40
Chestnut	160	53
Deal, Christiana	137	45
Elm	125	30
Hickory	250	55
Locust	295	80
Maple	202	65
Norway pine	123	40
Oak, African	208	50
" American white	230	50
" " live	245	55
" Canadian	146	36
" Dan	122	30
" Eng	140	35
" " superior	188	45
Pitch pine	136	45
" "	160	50
Riga fir	94	30
Teak	206	60
White pine	92	30
" American	130	45
Whitewood	116	38
	Lbs	
WROUGHT IRON.		
American	700	160 to 209
	650	
	600	
English	400	100 " 130
"	550	135 " 180
Swedish*	665	165 " 210
MIXTURE OF CAST AND WROUGHT IRON, etc,		
Cast iron, Blaenavon.	...	145
" 10 per ct. of wr't	...	175
" 30 " "	...	230
" 50 " "	...	185
" and 2½ per ct. of nickel, mean	...	180
" Stirling, 2d qu.	...	154
" " 3d "	...	125
Copper	...	55
Brass	...	58
STONES (American).		
Flagging, blue	31.	10
Freestone, Conn	13.	4
" Dorchester	10.8	3½
" N. Jersey	20 1	6½
	17.8	6
" N. York	24.	8
Granite, blue, coarse	18.	6
" Quincy, Mass.	26.	8½
STONES (English).		
Adelaide marble	4.5	1½
Arbroath	17.	5½
Bangor slate	90.	30
Bath	5,2	1¾
Caithness, paving, Sc.	68.	22
Cornish granite	22.	7
Craigleth sandstone	10.7	3½
Darley sandst., Vict'a	1.3	4
Kentish rag	35.8	12
Limestone	11.	3½
Llangollen slate	43.	14
Park Spring sandst'e	4.3	1.4
Portland oolite	21.2	7
Valentia, paving, Irel.	68.5	23
Welsh, "	157.	55
Yorkshire, blue	26.	8½
" landing	22.5	7½
" paving	10.4	3½

INCREASE IN STRENGTH OF SEVERAL WOODS BY SEASONING.

Ash........44.7 per cent.	Elm......12.3 per cent,	White pine....9 per cent.
Beech.....61.9 "	Oak.......26.1 "	

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* With 840 lbs. the deflection was 1 inch, and the elasticity of the metal destroyed.

CONCRETES, CEMENTS, ETC.

MATERIALS.	Breaking Weight.	MATERIALS.	Breaking Weight.
CONCRETES (English).		BRICKS (English).	
Fire-brick beam, Portl'd cem't	3.1	Best stock	11.8
" sand, 3 parts; lime, 1 part	.7	Fire-brick	14.
CEMENTS (English).		New brick	10.7
Blue clay and chalk	5.4	Old brick	9.1
Portland	37.5 10 2	Stock-brick, well burned " inferior, burned	5.8 2.5
Sheppy	5.		

TRANSVERSE STRENGTH OF CAST IRON BARS AND OAK BEAMS OF VARIOUS FIGURES.

Reduced to the uniform Measure of One Inch Square of Sectional Area, and One Foot in Length. Fixed at one end, Weight suspended from the other.

FORM OF BAR OR BEAM.	Breaking Weight.	FORM OF BAR OR BEAM.	Breaking Weight.
CAST IRON.	Lbs		Lbs
■ Square	673	▲ Equilateral triangle, an edge up	560
◆ Square, diagonal vertical	568	▼ Equilateral triangle, an edge down	958
● Cylinder	573	T 2 ins. deep × 2 ins. wide × .268 ins. depth	2068
◎ Hollow cylinder; greater diameter twice that of lesser	794	⊥ 2 ins. deep × 2 ins. wide × .268 ins. depth.	565
▮ Rectangular prism, 2 ins. deep × ½ in. depth	1456	OAK.	
" 3 ins. deep × ⅓ in. depth	2392	▲ Equilateral triangle, an edge up	114
" 4 " × ¼ "	2652	▼ Equilateral triangle, an edge down	130

TRANSVERSE STRENGTH OF SOLID AND HOLLOW CYLINDERS OF VARIOUS MATERIALS.

One foot in length. Fixed at one end; Weight suspended from the other.

MATERIALS.	Solid External Diameter.	Hollow Internal Diameter.	Breaking Weight.	Breaking Weight for 1 inch external Diameter and proportionate internal Diameter.
WOODS.	Ins.	Ins.	Lbs.	Lbs.
Ash	2.	...	685	86
"	2.	1.	604	75
Fir*	2.	...	772	97
White pine	I.	...	75	75
"	2.	...	610	76
METALS.				
Cast iron, cold blast	3.	...	12000	444
STONE WARE.				
Rolled pipe of fine clay	2.87	1.928	190	8

Brick-work.—A brick arch, having a rise of 2 feet, and a span of 15 feet 9 inches, and 2 feet in width, with a depth at its crown of 4 inches, bore 358,400 lbs. laid along its centre.

To Compute the Transverse Strength of a Rectangular Beam or Bar..—WHEN A BEAM OR BAR IS FIXED AT ONE END, AND LOADED AT THE OTHER.—*Rule.*—Multiply the *value* of the material in the preceding tables, or as may be ascertained, by the breadth and square of the depth in inches, and divide the product by the length in feet.

NOTE—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE.—What are the weights each that a cast and wrought iron bar, 2 inches square and projecting 30 inches in length, will bear without permanent injury?

The *values* for cast and wrought iron in this and the following calculations are assumed to be 225 and 180.

Hence $225 \times 2 \times 2^2 = 1800$, which, $\div 2.5 = 720$ lbs.; and $180 \times 2 \times 2^2 = 1440$, which, $\div 2.5 = 576$ lbs.

IF THE DIMENSIONS OF A BEAM OR BAR ARE REQUIRED TO SUPPORT A GIVEN WEIGHT AT ITS END.—*Rule.*—Divide the product of the weight and the length in feet by the *value* of the material, and the quotient will give the product of the breadth and the square of the depth.

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* An inch-square batten from the same plank as this specimen broke at 139 lbs.

EXAMPLE.—What is the depth of a wrought-iron beam, 2 inches broad, necessary to support 576 lbs. suspended at 30 inches from the fixed end?

$\frac{576\times2.5}{180}=8$, which, ÷2 ins. for the breadth=4, and $\sqrt{4}=2$ ins., the breadth.

WHEN A BEAM OR BAR IS FIXED AT BOTH ENDS, AND LOADED IN THE MIDDLE.—*Rule.*—Multiply the *value* of the material by 6 times the breadth and the square of the depth in inches, and divide the product by the length in feet.

NOTE.—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE—What weight will a bar of cast iron, 2 inches square and 5 feet in length, support in the middle, without permanent injury?

$225\times2\times6\times2^2=10800$, which, ÷5=2160 lbs.

OR, IF THE DIMENSIONS OF A BEAM OR BAR ARE REQUIRED TO SUPPORT A GIVEN WEIGHT IN THE MIDDLE, BETWEEN THE FIXED ENDS.—*Rule.*—Divide the product of the weight and the length in feet by 6 times the *value* of the material, and the quotient will give the product of the breadth and the square of the depth.

EXAMPLE.—What dimensions will a cast iron square bar 5 feet in length require to support without permanent injury a stress of 2160 lbs?

$\frac{2160\times5}{225\times6}=\frac{10800}{1350}=8$, which, ÷2 ins. for the assumed breadth, =4, and $\sqrt{4}=$ 2 ins the depth.

WHEN THE BREADTH OR DEPTH IS REQUIRED.—*Rule.*—Divide the product obtained by the preceding rules by the square of the depth, and the quotient is the breadth; or by the breadth, and the square root of the quotient is the depth.

ILLUSTRATION.—If 128 is the product, and the depth is 8: then $128\div8^2=2$, the breadth. Also, $123\div2=64$, and $\sqrt{64}=8$, the depth.

WHEN THE WEIGHT IS NOT IN THE MIDDLE BETWEEN THE ENDS.—*Rule.*—Multiply the *value* of the material by 3 times the length in feet, and the breadth and square of the depth in inches, and divide the product by twice the product of the distances of the weight, or stress from either end.

EXAMPLE.—What is the weight a cast-iron bar, fixed at both ends, 2 ins. square and 5 feet in length, will bear without permanent injury, 2 feet from one end?

$$\frac{225\times3\times5\times2\times2^2}{2\times2\times3}=\frac{27000}{12}=2250 \text{ lbs.}$$

WHEN A BEAM OR BAR IS SUPPORTED AT BOTH ENDS, AND LOADED IN THE MIDDLE.—*Rule.*—Multiply the *value* of the material by 4 times the breadth and the square of the depth in inches, and divide the product by the length in feet.

NOTE.—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE.—What weight will a cast-iron bar, 5 feet between the supports, and 2 ins. square, bear in the middle, without permanent injury?

$$225 \times 2 \times 4 \times 2^2 = 7200. \text{ which}, \div 5 = 1440 \text{ lbs.}$$

OR, IF THE DIMENSIONS ARE REQUIRED TO SUPPORT A GIVEN WEIGHT.—*Rule.*—Divide the product of the weight and length in feet by 3 times the *value* of the material, and the quotient will give the product of the breadth, and the square of the depth.

WHEN THE WEIGHT IS IN THE MIDDLE BETWEEN THE SUPPORTS.—*Rule.*—Multiply the *value* of the material by the length in feet, and the breadth, and the square of the depth in inches, and divide the product by the product of the distances of the weight, or stress from either support.

EXAMPLE.—What weight will a cast-iron bar, 2 ins. square and 5 feet in length, support without permanent injury, at a distance of 2 feet from one end, or support?

$$\frac{225 \times 5 \times 2 \times 2^2}{2 \times (5-2)} = \frac{9000}{6} = 1500 \text{ lbs.}$$

To Compute the Pressure upon the Ends or upon the Supports.—*Rule.*—1. Divide the product of the weight and its distance from the nearest end or support by the whole length, and the quotient will give the pressure upon the end or support farthest from the weight.

2. Divide the product of the weight and its distance from the farthest end, or support, by the whole length, and the quotient will give the pressure upon the end or support nearest the weight.

EXAMPLE.—What is the pressure upon the supports in the case of the preceding example?

$\frac{1500 \times 2}{5} = 600$ lbs. upon support farthest from the weight; $\frac{1500 \times 2}{5} = 900$ lbs. upon support nearest to the weight.

WHEN A BEAM OR BAR, FIXED OR SUPPORTED AT BOTH ENDS, BEARS TWO WEIGHTS AT UNEQUAL DISTANCES FROM THE ENDS. —Let m and n represent distances of greatest and least weights from their nearest end, W and w greatest and least weights, L whole length, l distance from least weight to farthest end, and l' distance of greatest weight from farthest end.

Then $\frac{m \times \mathrm{W}}{\mathrm{L}} + \frac{l \times w}{\mathrm{L}} =$ pressure at w end, and $\frac{n \times w}{\mathrm{L}} + \frac{l' \times \mathrm{W}}{\mathrm{L}} =$ pressure at W end.

ILLUSTRATION.—A beam 10 feet in length, having both ends fixed in a wall, bears two weights, viz., one of 1000 lbs. at 4 feet from one of its ends, and the other of 2000 lbs. at 4 feet from the other end; what is the pressure upon each end?

$\frac{4 \times 2000}{10} + \frac{6 \times 1000}{10} = 1400$ lbs. pressure upon w end, $\frac{4 \times 1000}{10} + \frac{6 \times 2000}{10} = 1600$ lbs. pressure at W end.

WHEN THE PLANE OF THE BEAM OR BAR PROJECTS OBLIQUELY UPWARD OR DOWNWARD.—WHEN FIXED AT ONE END AND LOADED AT THE OTHER.—*Rule.*—Multiply the *value* of the material by the breadth and square of the depth in inches, and divide the product by the product of the length in feet and the cosine of the angle of elevation or depression.

NOTE.—When the weight is laid uniformly along its length, the result must be doubled.

EXAMPLE.—What is the weight an ash-beam, 5 feet in length, 3 ins. square, and projecting upward at an angle of 7° 15′, will bear without permanent injury?

$$55\times3\times3^2=1485, \text{ which,}\div\overline{5\times\cos.\ 7^\circ\ 15'},=1485\div\overline{5\times.992}=299.39 \text{ lbs.}$$

To Compute the Transverse Strength of Cylinders, Ellipses, etc.—WHEN A CYLINDER, RECTANGLE (THE DIAGONAL BEING VERTICAL,) HOLLOW CYLINDER, OR BEAMS HAVING SECTIONS OF AN ELLIPSE, ARE EITHER FIXED AT ONE END AND LOADED AT THE OTHER, OR SUPPORTED AT BOTH ENDS, THE LOAD APPLIED IN THE MIDDLE, OR BETWEEN THE SUPPORTS.—*Rule.*—Proceed in all cases as if for a rectangular beam, taking for the breadth and depth, and *value* of the material, as follows:

Cylinder, $\text{diameter}^3\times.6$; Rectangle, * $\text{side}^3\times.7$; Hollow Cylinder $(\text{diam.}^2-\text{diam.}^3)\times.6$; Ellipse, transverse diam. vertical conj. $\times$ $\text{transverse}^2,\times.6$; and Ellipse, conj. diam. vert. transverse $\times$ $\text{conj.}^2\times.6$ of *value.*

When an Equilaterial Triangle, or ⊤ *Beam.* RULE.—Proceed in all cases as if for a rectangular beam, taking the following proportions of the *value* of the material.

Fixed at one or both ends.	Equilateral triangle,	edge up,	$b\times d^2,\times.2$	of *Value.*
	Equilateral triangle,	edge down,	$b\times d^2,\times 34$	"
	⊤ beam or bar,	edge down,	$b\times d^2,\times.42$	"
Supported at both ends.	Equilateral triangle,	edge up,	$b\times d^2,\times.34$	"
	Equilateral triangle,	edge down,	$b\times d^2,\times.2$	"
	⊤ beam or bar,	edge up,	$b\times d^2,\times.42$	"

To Compute the Diameter of a Solid Cylinder to Support a Given Weight.—WHEN FIXED AT ONE END, AND LOADED AT THE OTHER.—*Rule.*—Multiply the weight to be supported in pounds by the length of the cylinder in feet; divide the product by .6 of the *value* of the material, and the cube root of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly throughout its length, the cube root of half the quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast-iron cylindrical beam, 8 ins. in length, to support 15000 lbs. without permanent injury?

$$3 \text{ ins.}=.66 \text{ feet; } \frac{15000\times.66}{.6\times225}=74.07\text{; and } \sqrt[3]{74.07}=4.2.$$

WHEN FIXED AT BOTH ENDS, AND LOADED IN THE MIDDLE.—*Rule.*—Multiply the weight to be supported in pounds by the length

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The strength of a Rectangle, the diagonal being vertical, compared to that of its circumscribing rectangle, when the direction of the strain is parallel to the side of it, is as 2.45 to 1.

of the cylinder between the supports in feet; divide the product by .6 of the *value* of the material, and the cube root of ¼ of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly along its length, the cube root of half the quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast-iron cylinder, 2 feet between the supports, that will support 19305 lbs. without permanent injury?

$$\frac{19305\times2}{.6\times225}=286, \text{ and } \sqrt[3]{\frac{286}{6}}=3.61 \text{ ins.}$$

WHEN SUPPORTED AT BOTH ENDS, AND LOADED IN THE MIDDLE.—*Rule.*—Multiply the weight to be supported in pounds by the length of the cylinder between the supports in feet; divide the product by .6 of the *value* of material, and the cube root of ¼ of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly along its length, the cube root of half quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast-iron cylinder, 2 feet between the supports, that will support 54000 lbs. without permanent injury?

$$\frac{54000\times2}{.\times225}=800, \text{ and } \sqrt[3]{\frac{800}{4}}=5.85 \text{ ins.}$$

And what its diameter if loaded uniformly along its length?

$$\frac{800\div2}{4}=100, \text{ and } \sqrt[3]{100}=4.64 \text{ ins.}$$

To Compute the Relative Value of Materials to resist a Transverse Strain.—Let V represent this value in a Beam, Bar, or Cylinder, one foot in length, and one inch square, side, or in diameter; W the weight; l the length in feet; b the breadth, and d the depth in inches; m the distance of the weight from one end; and n the distance of it from the other in feet.

NOTE.—In cylinders, for $b\,d^2$ put d^3.

1. Fixed at one End, weight suspended from the other, $\frac{l\,W}{b\,d^2}=V$.

2. Fixed at both Ends, weight suspended from the middle, $\frac{l\,W}{6\,b\,d^2}=V$.

3. Supported at both Ends, weight suspended from the middle $\frac{l\,W}{4\,b\,d^2}=V$.

4. Supported at both Ends, weight suspended at any other point than the middle, $\frac{m\,n\,W}{l\,b\,d^2}=V$.

5. Fixed at both Ends, weight suspended at any other point than the middle, $\frac{2\,m\,n\,W}{3\,l\,b\,d^2}=V$.

From which formulæ, the weight that may be borne, or any of the dimensions, may be computed by the following:

1. $\frac{V\,d\,b^2}{l}=W;\frac{V\,b\,d^2}{W}=l;\frac{l\,W}{V d^2}=b:\sqrt{\frac{l\,W}{b\,V}}=d.$ In rectangular beams, etc., b and $d=\sqrt[3]{\frac{l\,W}{V}}$.

2. $\frac{6\,b\,d^2\,V}{l}=W;\frac{6\,b\,d^3\,V}{W}=l;\frac{l\,W}{6\,d^2\,V}=b;\sqrt{\frac{l\,W}{6\,b\,V}}=d.$ In rectangular beams, etc., b and $d=\sqrt[3]{\frac{l\,W}{6\,V}}$.

3. $\frac{4\,b\,d^2\,V}{l}=W;\frac{4\,b\,d^2\,V}{W}=l;\frac{l\,W}{4\,d^2 V}=b:\sqrt{\frac{l\,W}{4\,b\,V}}=d.$ In rectangular beams. etc., b and $d=\sqrt[3]{\frac{l\,W}{4\,V}}$.

4. $\frac{l\,b\,d^2\,V}{m\,n}=W,\frac{m\,n\,W}{b\,d^2\,V}=l;\frac{m\,n\,W}{l\,d^3\,V}=b;\sqrt{\frac{m\,n\,W}{l\,b\,V}}=d.$ In rectangular beams, etc., b and $d=\sqrt[3]{\frac{m\,n\,W}{l\,V}}$.

5. $\frac{3\,l\,b\,d^2\,V}{2\,m\,n}=W;\frac{2\,m\,n\,W}{3\,b\,d^2\,V}=l;\frac{2\,m\,n\,W}{3\,l\,d^2\,V}=b;\sqrt{\frac{2\,m\,n\,W}{3\,l\,b\,V}}=d.$ In rectangular beams, etc., b and $d=\sqrt[3]{\frac{2\,m\,n\,W}{3\,l\,V}}$.

When the weight is uniformly distributed, the same formulæ will apply, *W* representing only half the required or given weight.

Girders, Beams, Lintels, etc.—*The Transverse or Lateral Strength of any Girder, Beam Brest-summer, Lintel,* etc., is in proportion to the product of its breadth and the square of its depth, and also to the area of its cross-section.

The *best form of section* for cast-iron girders or beams, etc., is deduced from the experiments of Mr. E. Hodgkinson, and such as have this form of section ⌶ are known as Hodgkinson's.

The rule deduced from his experiments directs that the area of the bottom flange should be 6 times that of the top flange—flanges connected by a thin vertical web, sufficiently rigid, however, to give the requisite lateral stiffness, and tapering both upward and downward from the neutral axis; and in order to set aside the risk of an imperfect casting, by any great disproportion between the web and the flanges, it should be tapered so as to connect with them, with a thickness corresponding to that of the flange.

As both cast and wrought iron resist crushing or compression with a greater force than extension, it follows that the flange of a girder or beam of either of these metals, which is subjected to a crushing strain, according as the girder or beam is *supported at both* *ends, or fixed at one end*, should be of less area than the other flange, which is subjected to extension or a tensile strain.

When *girders are subjected to impulses*, and are used to sustain vibrating loads, as in bridges, etc., the best proportion between the top and bottom flange is as 1 to 4: as a general rule, they should be as narrow and deep as practicable, and should never be deflected to more than one five-hundredth of their length.

In *Public Halls, Churches and Buildings* where the weight of people alone is to be provided for, an estimate of 175 lbs. per square foot of floor surface is sufficient to provide for the weight of flooring and the load upon it.

In churches, buildings, etc., the weight to be provided for should be estimated at that which may at any time be placed thereon, or which at any time may bear upon any portion of their floors; the usual allowance, however, is for a weight of 280 lbs. per square foot of floor surface for stores and factories, and 175 lbs. per square foot when the weight of people alone is to be provided for.

In all uses, such as in buildings and bridges, where the structure is exposed to sudden impulses, the load or stress to be sustained should not exceed from 1-5 to 1-6 of the breaking weight of the material employed; but when the load is uniform or the stress quiescent, it may be increased to ⅓ and ¼ of the breaking weight.

An *open-web girder or beam*, etc., is to be estimated in its resistance on the same principle as if it had a solid web. In cast metals, allowance is to be made for the loss of strength due to the unequal contraction in cooling of the web and flanges.

In *cast-iron*, the mean resistance to *crushing or extension* is as 4.3 to 1, and in wrought iron as 1.35 to 1; hence the mass of metal below the neutral axis will be greatest in these proportions when the stress is intermediate between the ends or supports of the girders, etc.

Wooden girders or beams, when sawed in two or more pieces, and have slips set between them, and the whole bolted together, are made stiffer by the operation, and are rendered less liable to decay.

Girders cast with a face up are stronger than when cast on a side, in the proportion to 1 to .96, and they are strongest also when cast with the bottom flange up.

The following results of the resistances of metals will show how the material should be distributed in order to obtain the *maximum* of strength with the *minimum* of material:

	To Tension	To Crushing.
Cast-iron..	21,000 32,000	90,300 140,000
Copper..	24,250	117,000
Wrought-iron..................................	45,000 72,000	40,000 83,000

The best iron has the greatest tensile strength, and the least compressive or crushing.

The *most economical construction of a girder or beam*, with reference to attaining the greatest strength with the least material, is as follows: The outline of the top, bottom and sides should be a curve of various forms, according as the breadth or depth throughout is equal, and as the girder or beam is loaded only at one end, or in the middle, or uniformly throughout.

To Compute the Dimensions and Form of a Girder or Beam.—WHEN A GIRDER OR BEAM IS FIXED AT ONE END, AND LOADED AT THE OTHER.—1. *When the depth is uniform throughout the entire length.*—The section at every point must be in proportion to the product of the length, breadth and square of the depth, and as the square of the depth is in every point the same, the breadth must vary directly as the length; consequently, each side of the beam must be a vertical plane, tapering gradually to the end.

2. *When the breadth is uniform throughout the entire length.*—The depth must vary as the square root of the length; hence the upper or lower sides, or both, must be determined by a parabolic curve.

3. *When the section at every point is similar—that is, a Circle, an Ellipse, a Square, or a Rectangle, the sides of which bear a fixed proportion to each other.*—The section at every point being a regular figure, for a circle, the diameter at every point must be as the cube root of the length; and for an ellipse, or a rectangle, the breadth and depth must vary as the cube root of the length.

WHEN A GIRDER OR BEAM IS FIXED AT ONE END AND LOADED UNIFORMLY THROUGHOUT ITS LENGTH.—1. *When the depth is uniform throughout its entire length.*—The breadth must increase as the square of the length.

2. *When the breadth is uniform throughout its entire length.*—The depth will vary directly as the length.

3. *When the section at every point is similar, as a Circle, Ellipse, Square, and Rectangle.*—The section at every point being a regular figure, the cube of the depth must be in the ratio of the square of the length.

WHEN A GIRDER OR BEAM IS SUPPORTED AT BOTH ENDS.—1. *When loaded in the middle.*—The *constant* of the beam, or the product of the breadth and the square of the depth, must be in proportion to the distance from the nearest support; consequently, whether the lines forming the beam are straight or curved, they meet in the centre, and of course the two halves are alike: the beam, therefore, may be considered as one half the length, the supported end corresponding with the free end in the case of beams, one end being fixed, and the middle of the beams similarly corresponding with the fixed end.

2. *When the depth is uniform throughout.*—The breadth must be in the ratio of the length.

3. *When the breadth is uniform throughout.*—The depth will vary as the square root of the length.

4. *When the section at every point is similar, as a Circle, Ellipse,*

Square, and Rectangle.—The section at every point being a regular figure, the cube of the depth will be as the square of the distance from the supported end.

WHEN A GIRDER OR BEAM IS SUPPORTED AT BOTH ENDS, AND LOADED UNIFORMLY THROUGHOUT ITS LENGTH. 1. *When the depth is uniform.*—The breadth will be as the product of the length of the beam and the length of it on one side of the given point, less the square of the length on one side of the given point.

2. *When the breadth is uniform.*—The depth will be as the square root of the product of the length of the beam and the length of it on one side of the given point, less the square of the length on one side of the given point.

3. *When the section at every point is similar, as a Circle, Ellipse, Square, and Rectangle.*—The section at every point being a regular figure, the cube of the depth will be as the product of the length of the beam and the length of it on one side of the given point, less the square of the length on one side of the given point.

GENERAL DEDUCTIONS FROM THE EXPERIMENTS OF STEPHENSON, FAIRBAIRN, CUBITT, HUGHES, ETC. Fairbairn shows in his experiments that with a stress of about 12,320 lbs. per square inch on cast iron, and 28,000 lbs. on wrought iron, the sets and elongations are nearly equal to each other.

A cast-iron beam will be bent to one-third of its breaking weight if the load is laid on gradually; and one-sixth of it, if laid on at once, will produce the same effect, if the weight of the beam is small compared with the weight laid on. Hence beams of cast iron should be made capable of bearing more than 6 times the greatest weight which will be laid upon them.

In wrought-iron beams, if fixed at both ends, the upper flange should be larger than the lower, in the ratio of 1.35 to 1.

The breaking weights in similar beams are to each other as the squares of their like linear dimensions; that is, the breaking weights of beams are computed by multiplying together the area of their section, their depth, and a *constant*, determined from experiments on beams of the particular form under investigation, and dividing the product by the distance between the supports.

Cast and wrought iron beams, having similar resistances, have weights nearly as 2.44 to 1.

The range of the comparative strength of girders of the same depth, having a top and bottom flange, and those having bottom flange alone, is from having but a little area of bottom flange to a large proportion of it, from ½ to ¼ greater strength.

A box beam or girder, constructed of plates of wrought iron, compared to a single rib and flanged beam **I**, of equal weights, has a resistance as 100 to 93.

The resistance of beams or girders, where the depth is greater than their breadth, when supported at top, is much increased. In some cases the difference is fully one third

When a beam is of equal thickness throughout its depth, the curve should be an *ellipse* to enable it to support a uniform load with equal resistance in every part; and if the beam is an open one, the curve of equilibrium, for a uniform load, should be that of a *parabola.* Hence, when the middle portion is not wholly removed, the curve should be a compound of an ellipse and a parabola, approaching nearer to the latter as the middle part is decreased.

Girders of cast iron, up to a span of 40 feet, involve a less cost than of wrought iron.

Cast iron beams and girders should not be loaded to exceed one-fifth of their breaking weight; and when the strain is attended with concussion and vibration, this proportion must be increased.

Simple cast iron girders may be made 50 feet in length, and the best form is that of Hodgkinson: when subjected to a fixed load, the flange should be as 1 to 6, and when to a concussion, etc., as 1 to 4.

The forms of girders for spaces exceeding the limit of those of simple cast iron are various; the principal ones adopted are those of the straight or arched cast iron girders in separate pieces, and bolted together—the Trussed, the Bow-string, and the wrought iron Box and Tubular.

A *Straight* or *Arched Girder* is formed of separate castings, and is entirely dependent upon the bolts of connection for its strength.

A *Trussed* or *Bow-string Girder* is made of one or more castings to a single piece, and its strength depends, other than upon the depth or area of it, upon the proper adjustment of the tension, or the initial strain, upon the wrought iron truss.

A *Box* or *Tubular Girder* is made of wrought iron, and is best constructed with cast iron tops, in order to resist compression: this form of girder is best adapted to afford lateral stiffness.

Floor Beams, Girders, etc.—The condition of the stress borne by a floor beam is that of a beam supported at both ends and uniformly loaded; but from the irregularity in its loading and unloading, and from the necessity of its possessing great rigidity, it is impracticable to estimate its capacity other than as a beam having the weight borne upon the middle of its length.

To Compute the Depth of a Floor Beam.—When the Length and Breadth are given, and the Distance between the Centres of the Beam is One Foot.—*Rule.*—Divide the product of the square of the length in feet and the weight to be borne in pounds per square foot of floor, by the product of 4 times the breadth aud the *value* of the material from the Table (page 208,) and the square root of the quotient will give the depth of the beam in inches.

Example.—A white pine beam is 2 ins. wide, and 12 feet in length between the supports; what should be the depth of it to support a weight of 175 lbs. per square foot?

$$\frac{12^2 \times 175}{2 \times 4 \times 30} = 105, \text{ and } \sqrt{105} = 10.25 \text{ ins.}$$

When the Distance between the Centres of the Beam is greater or less than One Foot.—*Rule.*—Divide the product of the square of the depth for a beam, *when the distance between the centres is one foot*, by the distance given in inches by 12, and the square root of the quotient will give the depth of the beam in inches.

EXAMPLE.—Assume the beam in the preceding case to be set 15 ins. from the centres of its adjoining beams; what should be its depth?

$$\frac{10.25^2\times 15}{12}=131.25, \text{ and } \sqrt{131.25}=11.45 \text{ ins.}$$

Header and Trimmer Beams.—The conditions of the stress borne or to be provided for by them are as follows:

Header or *Trimmer* beams support ½ of the weight of and upon the tail beams inserted into or attached to them.

Trimmer Beams support, in addition to that borne by them directly as a floor beam, each ½ the weight on the headers.

The stress, therefore, upon a header is due directly to its length, or the number of tail beams it supports; and the stress upon the trimmer beams is that of their own stress as a floor beam, and ½ of the weight upon the header supported by them.

NOTE.—The distance between the support of the trimmer-beams and the point of connection with the header does not in anywise affect the stress upon the trimmer-beams; for in just proportion as this distance is increased, and the stress upon them consequently increased, by the suspension of the header from them nearer to the middle of their length, so is the area of their surface supported by the header reduced, and, consequently, the load to be borne by it.

Girder.—The condition of the stress borne by a Girder* is that of a beam fixed or supported at both ends, as the case may be, supporting the weight borne by all of the beams resting thereon, at the points at which they rest; and its dimensions must be proportionate to the stress upon it, and the distance between its points of insertion or support.

ILLUSTRATION.—It is required to determine the dimensions of a pitch-pine girder, 15 feet between its several points of supports, to support the ends of two lengths of beams each 20 feet in length, having a superincumbent weight, including that of the beams, of 200 lbs. per square foot.

The condition of the stress upon such a girder would be that of a number of beams, 40 feet in length (20×2), supported at both ends, and loaded uniformly along their length, with 200 lbs. upon every superficial foot of their area.

Hence the amount of the weight to be borne is determined by $20\times 2\times 15\times 200=120{,}000$ lbs.= the product of twice the length of a beam, the distance between the supports of the girder and the weight borne per square foot of area; and the resistance to be provided for is that to be borne by a beam, 15 feet in length, fixed at both ends, and supporting 120,000 lbs. uniformly laid along its length, equal to 60,000 lbs. supported at its centre.

Consequently, $\frac{15\times 60{,}000}{6\times 50}=3000$=quotient of the product of the length and weight ÷ the product of 6 times the value of the material: and assuming the girder to be 12 inches wide, then $\sqrt{\frac{3000}{12}}=15.8$ ins.

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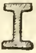
*When a girder has four or more supports, its condition as regards a stress upon its middle is that of a beam fixed at both ends.

FORMULÆ TO COMPUTE THE VALUES AND THE DIMENSIONS OF BEAMS, BARS, ETC., OF VARIOUS SECTIONS.—(TREDGOLD.)

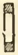
For a Square, Rectangle, Rectangle the diagonal being vertical, and Cylinder, they are alike to those already given, substituting in the Rectangles for $b\ d^2$. S^3.

For a Grooved or Double-flanged, Open, and Single-flanged Beam they are as follows:

Grooved.



Open.



	Grooved.	Open.
1. *Fixed at one End*, Weight suspended from the other,	$\dfrac{l\mathrm{W}}{b\ d^2\,(1-q\ y^3)}=\mathrm{V}.$	$\dfrac{l\mathrm{W}}{b\ d^2\,(1-y^3)}=\mathrm{V}.$
2. *Fixed at both Ends*, Weight suspended from the middle,	$\dfrac{l\mathrm{W}}{b\ d^2\,(1-q\ y^3)}=\mathrm{V}.$	$\dfrac{l\ \mathrm{W}}{b\ d^2\,(1-y^3)}=\mathrm{V}.$
3. *Supported at both Ends*, Weigh suspended from the middle,	$\dfrac{l\mathrm{W}}{b\ d^2\,(1-q\ y^3)}=\mathrm{V}.$	$\dfrac{l\mathrm{W}}{b\ d^2\,(1-y^3)}=\mathrm{V}.$
4. *Supported at both Ends*, Weight suspended at any other point than the middle,	$\dfrac{m\ n\ \mathrm{W}}{b\ d^2\ \overline{m+n}\ (1-q\ y^3)}=\mathrm{V}.$	$\dfrac{m\ n\ \mathrm{W}}{b\ d^2\ \overline{m+n}\ (1-y^3)}=\mathrm{V}.$
5. *Fixed at both Ends*, Weight suspended from any other p't than the middle,	$\dfrac{m\ n\ \mathrm{W}}{b\ d^2\ \overline{m+n}\ (1-q\ y^3)}=\mathrm{V}.$	$\dfrac{m\ n\ \mathrm{W}}{b\ d^2\ \overline{m+n}\ (1-y^3)}=\mathrm{V}.$

Single-flanged

$$1.\ \dfrac{l\ \mathrm{W}}{\dfrac{b\ d^2\ (1-q\ y^3)\ (1-q)}{(\sqrt{1-q\,y^3}\ +\ \sqrt{1-q})^2}}=\mathrm{V}.$$

2., 3., 4., 5. For the other conditions of a Beam, Bar, etc., use the same formula as the above, multiplying the *Value* obtained above by 6, 4, 1 and 1.5 respectively, y and q representing $\dfrac{\text{depth of groove}}{\text{whole depth of beam}}=y$, and $\dfrac{\text{whole breadth of beam}-\text{width of web}}{\text{whole breadth of beam}}=q$.

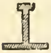
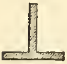
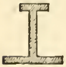
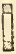
TRANSVERSE RESISTANCE FROM END PRESSURE APPLIED HORIZONTALLY.

WROUGHT IRON.—7½ feet in length; flanges, 6×3½ ins. × ⅝ depth; area, 5½ square ins.; 50,000 lbs. produced no set; 58,240 lbs. produced a set of 1¾ ins.

WHITE OAK.—Rectangle 10 feet in length, 11×4½ ins.; 33,600 lbs. gave a deflection of .⅜ in.; 50.400 lbs. gave a deflection of .5 in.; 67,200 lbs. gave a deflection of .⅝ and with 78,400 it broke.

TRANSVERSE STRENGTH OF CAST-IRON GIRDERS AND BEAMS, DEDUCED FROM EXPERIMENTS IN ENGLAND AND AMERICA.

Reduced to a Uniform Measure of One Inch in Depth, One Foot in Length, Supported at both Ends; the Stress or Weight applied in the Middle.

SECTION OF GIRDER OR BEAM.	Flanges.		Width of Vertical Web.	Depth of Girder.	Breadth of Girder.	Area of Section in Centre.	Breaking Weight at Length of one foot.	Strength per Sq. Inch of Section.	Value for Breaking Weight = $\frac{l\,W}{A\,d}$ = V.‡
	Top.	Bottom.							
	Sq. Ins	Sq. Ins.	In.	In.	In.	Sq I.	Lbs.	Lbs.	Lbs.
Eq. area of flange at top & bottom,	1.75×.42 =.735	1.77×.39 =.69	.29	5.125	1.77	2.82	30150	10768	2100
do.	2.02×.515 =1.045	2.02×.515 =1.045	.51*	2 02	2.02	2.59	10276	3952	1900
 Area of sec. of top & bot. I to 6,	2.23×.31 =.72	6.67×.66 = 4.4	.266	5.125	6.67	6.23	117450	18852	3650
	....	5 ×.3 = 1.5	.365	1.56	5.	1.96	7280	3714	2350
	5 ×.3 =1.5	....	.365	1.56	5.	1.96	2366	1213	760
	....	23.9×3.12 = 74.56	3.3	36.1	23.9	183.5	8066240	43958	1200
	5 ×.5 =.25	1.5×.5 = .75	.5	4.†	1.5	1.	19980	19980	5000
	1 5×.5 =.75	.5×.5 = .25	.5	4.†	1.5	1.	7252	7252	1800
	4 ×2 = 8	....	2.	4.	4.	12.	33600	2800	700
	5.1 ×2 33 = 11.88	12.1×2.07 = 25.04	2.08	30.5	11.1	90.8	4793800	52795	1700
Rectangular Prism,	....	....	.994	2.012	2.994	2.025	9440	4662	2350
 Open Beam.	1.005×.98	1.005×.99	1.005	2.51	1.005	1.98	12340	6232	2450
	.995×1.01	.995× 1	.995	3.01	.995	2.	15420	7710	2550
	1.005×.98	1.005×.99	1.005	.4	1.005	1.98	21765	10992	2700
	.771×1.51	.771×1.5	.771	4.04	.771	2.322	25705	11070	2750
	1.507×.74	1.507×.74	1.507	4.04	1.507	2.23	25735	11540	2850
	1.525×.78	1.525×.78	1.525	4.07	1.525	2.35	30000	12689	3100
Square Prism, Stress at Side,	....	....	1.02	1.01	1,02	1.032	2635	2552	2500
Cylinder,	....	....	1.122	1.122	1.122	.989	2370	2396	2150
Square Prism, angle up.	....	....	.4431	1.443	1.443	1.041	2269	2182	1500

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* Horizontal web.

† Depth of opening 3 inches.

‡ A representing area of section, d the depth in inches, l the length in feet, and W the breaking weight in pounds.

CRUSHING STRENGTH OF VARIOUS MATERIALS, DEDUCED FROM EXPERIMENTS IN ENGLAND AND AMERICA.

Reduced to a uniform Measure of One Square Inch.

FIGURES AND MATERIAL.	Crushing Weight.	FIGURES AND MATERIAL.	Crushing Weight.
Prisms.	Lbs.		Lbs.
CAST IRON.		Clay, fine, baked	175
American, gun-metal	174803	" " rolled and baked	400
" mean	129000	Common brick masonry	800 500
English, Low Moor, No. 1	62450		
" " No. 2	92330	Crown glass	31000
" Clyde, No. 3	106039	Craigleith Limestone, Eng'h	7300 2185
" Stirling, mean of all	122395		
" " extreme	134400	Aberdeen granite, "	8400 10363
WROUGHT IRON.			
American	127720	Arbroath "	7884
" mean	83500	Caithness "	6493
English	65200 40000	Limestone "	3065
VARIOUS METALS.		Portland "	15583 4570
Fine brass	104800	Portland cement "	15000
Cast copper	117000	" mean "	8200
Cast steel	295000	Portland oolite "	3850
Cast tin	15500	Fire-brick, Stourbridge	1717
Lead	7730	Freestone, Bellville	3522
WOODS.		" Caen	1088
Ash	6663	" Connecticut	3319
Beech	6963	" Dorchester	3069
Birch	7969	" Little Falls	2991
Box	10513	Gneiss	19600
Cedar, red	5968	Granite, Patapsco	5340
Chestnut	5350	" Quincy	15300
Elm	6831	Marble, Baltimore, large	8057
Hickory, white	8925	" " small	18061
Locust	9113	" East Chester*	23917
Mahogany, Spanish	8198	" Hastings, N. Y	18941
Maple	8150	" Italian	12624
Oak, American white	6100	" Lee, Mass	22702
" Canadian white	5982	" Montgomery co., Pa	8950
" " live	6850	" Stockbridge†	10382
" English	9500 6484	" Symington, large	11156
		" " fine crystal	18248
Pine, pitch	8947	" " strata horizontal	10124
" white	5775	" " strata vertical	9324
" yellow	8200	Mortar, good	240
Spruce, white	5950	" common	120
Sycamore	7082	Normandy Caen	1543
Teak	12100	Portland cement, 1; sand, 1	1280
Walnut	6645	Roman "	342
STONES, CEMENTS, ETC.		Sandstone, Adelaide	2800
Brick, hard	2000 4368	" Acquia Creek‡	5340
		" Seneca§	10762
" common	4000 800	Stock brick	2177
		Sydney "	2228

* Same as that of the General Post Office. Washington.

† Same as that of the City Hall. New York.

‡ Same as that of the Capitol, Treasury Department, and Patent Office, Washington, D. C.

§ Same as that of the Smithsonian Institute.

‖ Same as that of the National Washington Monument.

CRUSHING STRENGTH.

The *crushing strength* of any body is in proportion to the area of its section, and inversely as its height. In tapered columns, the strength is determined by the least diameter.

When the height of a *prism or column* is not 5 times its side or diameter, the crushing strength is at its maximum.

Experiments upon *cast-iron bars* give a *crushing stress* of 5,000 lbs. per square inch of section as just sufficient to overcome the elasticity of the metal; and when the height exceeds 3 times the diameter, the iron yields by bending.

When it is 10 times, it is reduced as 1 to 1.75; when it is 15 times, it is reduced as 1 to 2; when it is 20 times, it is reduced as 1 to 3; when it is 30 times, it is reduced as 1 to 4; and when it is 40 times, it is reduced as 1 to 6.

The experiment of Mr. Hodgkinson have determined that an increase of strength of about ⅛ of the breaking weight is obtained by *enlarging the diameter of the column in its middle.*

In cast iron columns of the same thickness, the strength is inversely proportional to the $^{1\cdot7}$ power of the length nearly. Thus in solid columns, the ends being flat, the strength is as $\frac{d^{3\cdot6}}{l^{1\cdot7}}$, l representing the length, and d the diameter.

Hollow columns, having a greater diameter at one end than the other, have not any additional strength over that of uniform cylindrical columns.

Experiment upon *wrought iron* give a *mean crushing stress* of 74,250 lbs. per square inch. Cast iron is decreased in length nearly double what wrought iron is by the same weight; but wrought iron will sink to any degree with little more than 26680 lbs. per square inch, while cast iron will bear 97500 lbs. to produce the same effect.

A *wrought bar* will bear a *compression* of 1-863 of its length, without its utility being destroyed.

With *cast iron*, a pressure beyond 26680 lbs. per square inch is of little, if any, use in practice.

For equal decrements of length, wrought iron will sustain double the pressure of cast iron.

Glass and *the hardest stones* have a *crushing strength* from 7 to 9 times greater than tensile; hence an approximate value of their crushing strength may be obtained from their tensile, and contrariwise.

Various experiments show that the power of *stones*, &c., to resist the effects of *freezing* is a fair exponent of that to resist compression.

WROUGHT IRON PLATES, CYLINDRICAL TUBES.

LENGTH.	Width.	Thickness.	Area.	Crushing Weight.
PLATES.	Ins.	Ins.	Ins.	Lbs.
10 feet	2.98	.497	1.48	815
10 "	3.01	.766	2.3	3379
HOLLOW CYLINDERS.	External.	Internal.		
10 feet	1.495	1.292	.444	14661
10 "	2.49	2.275	.804	29779
10 "	6.366	6.106	2.547	35886
RECTANGULAR TUBES.				
10 lap-riveted	4.1	4.1	.504	10980
10 lap-riveted	4.1	4.1	1.02	19261
10 lap-riveted	4.25	4.25	2.395	21585
10 lap-riveted	8.4	4.25	6.89	29981
10 lap-riveted	8.1	8.1	2.07	132760
10 lap-riveted, and two internal diaphragm plates	8.1	8.1	3.551	19800

EXPANSION OR DILATATION OF SOLIDS.—(FARADAY.)

Lineal.

At 212°, the length of the bar at 32°=1.

Bismuth	1.0013908	Gold	1.001495	Silver	1.00201
Brass	1.0019062	Granite	1.0007894	Slate	1.0011436
Cast iron	1.0011112	Lead	1.0028426	Stock brick	1.0005502
Cement	1.001435	Marble	1.0011041	Steel	1.0011899
Copper	1.001435	Pavements	1.0008985	Tin	1.002
Fire-brick	1.0004928	Platinum	1.0009542	Wrought iron	1.0012575
Glass	1.0008545	Sandstone	1.001743	Zinc	1.002042

DAMS AND TUNNELS.

DAMS (EARTHWORK.)

Width at top in high dams from 7 to 20 ft.

Width at top in low dams......... = height.

Breast slopes.......... = 3 to 1

Back slopes............ = 2 to 1

Height above surface of water not less than 3.5 feet.

PROPORTION OF LABORERS IN BANK, FILLERS, AND WHEELERS IN DIFFERENT SOILS, WHEELERS BEING ESTIMATED FOR A DISTANCE OF FIFTY YARDS.

	Getters.	Fillers.	Wheelers.		Getters.	Fillers.	Wheelers.
In loose earth, sand, etc	1	1	1	In hard clay	1	1¼	1¼
In compact earth	1	2	2	In compact gravel	1	1	1
In marl	1	2	2	In rock	3	1	1

MASONRY.

Width at bottom = .7 height; at middle = .5 height; and at top = .3 height.

TUNNELS.—(From Actual Practice in Brickwork.)

PURPOSE.	Formation of Strata.	Extreme Height.		Extreme Width.		Depth at Crown.	
		Feet.	Ins.	Feet.	Ins.	Feet.	Ins.
Canal	Various	16	2	17		1	3
Canal	Clay	21	6	20		1	6
Thames Tunnel	Clay	22	3	37	6	2	6
Railway	Chalk	26	6	27		1	6
"	Various	27	6	27		1	10½
"	Shale	30		30		1	10½
"	Green sand	30	6	30		2	3
"	Freestone	36		36		2	3
Canal	Chalk and earth	39		35	6	1	2

WIND-MILLS.—(Molesworth.)

To Compute the Angles of the Sails.

$23° - \frac{18 d^2}{r^2}$ = angle of the sail with the plane of motion at any part of the sail; r representing radius of sail in feet, and d distance of any part of the sail from the axis.

Axis of Shaft of Wind-mill with Horizon.

8° upon level ground.
Breadth of whip at axis, $\frac{1}{30}$ length of whip.
Depth " " $\frac{1}{40}$ "
Breadth of whip at end, $\frac{1}{60}$ "
Depth " " $\frac{1}{80}$ "
Width of sail " $\frac{1}{3}$ "

Divided by the whip in the proportion of 5 to 3, the narrowest portion being nearest to the wind.

Width of sail at axis, $\frac{1}{5}$ length of whip; distance of sail from axis, $\frac{1}{7}$ length of whip.

Cross-bars from 16 to 18 inches apart.

STRENGTH OF ICE.

Thickness, 2 ins. will bear infantry.
" 4 " cavalry or light guns.
" 6 " heavy field guns.
" 8 " upon sledges, a weight not exceeding 1000 lbs. per square foot.

STIFFNESS OF BEAMS.

Stiffness of Beams.—(TREDGOLD.)

$\sqrt[3]{\frac{l^2 \, W \, C}{b}} = d$; $\frac{l^2 \, W \, C}{d^3} = b$; b representing breadth, and d depth in inches, l length in feet, and W load in lbs. upon the middle.

C = Pine, .01; Ash, .01; Beech, .013; Elm, .015; Oak, .13; Teak, .008.

When the beam is uniformly loaded, put .625 W instead of W.

Resistance to Detrusion.—When one beam is let in, at an inclination to the depth of another, so as to bear in the direction of the fibres of the beam that is cut, the depth of the cut *at right angles to the fibres* should not be more than one-fifth of the length of the piece, the fibres of which, by their cohesion, resist the pressure.

To Compute the Length necessary to resist a given Horizontal Thrust, as in the Case of a Rafter let into a Tie-Beam.

$\frac{4T}{bc} = l$; b representing the breadth of the beam in inches, T the horizontal thrust in lbs., c the cohesive resistance of the material in lbs. per square inch, and l the length in inches.

REVOLVING DISC.

To Compute the Power.—RULE. Multiply one-half the weight of the disc by the height due to the velocity of its circumference in feet per second.

EXAMPLE.—A grind-stone 3⅜ feet in diameter, weighing 2000 lbs., is required to make 362¼ revolutions per minute; what power must be communicated to it?

Circum. of 3⅜ = 10.6 feet, which × 362.25 and ÷ 60 = 64 feet per second. Then 2000 ÷ 2 × 64 = 64000 lbs. raised 1 foot.

NOTE.—If the revolving disc is not an entire or solid wheel, being a ring or annulus, it must first be computed as if an entire disc, and then the portion wanting must be computed and deducted.

Power Concentrated in Moving Bodies.—Simple power is *force multiplied by its velocity.* Power concentrated in a moving body is the *weight of the body multiplied by the square of its velocity; and the product divided by the acceleratrix*, or the power concentrated in a moving body is equal to the power expended in generating the motion.

SHRINKAGE OF CASTINGS.

	In.
Iron, small cylinders	= $\frac{1}{16}$ per foot.
" Pipes	= $\frac{1}{8}$ "
" Girders, beams, etc.	= $\frac{1}{8}$ in 15 ins.
" Large cylinders, the contraction of diameter at top	= $\frac{1}{16}$ per foot.
" Ditto at bottom	= $\frac{1}{12}$ per foot.
" Ditto in length	= $\frac{1}{8}$ in 16 ins.

Brass, thin .... = $\frac{1}{8}$ in 9 ins.
Brass, thick .... = $\frac{1}{8}$ in 10 ins.
Zinc .... = $\frac{5}{16}$ in a foot.
Lead .... = $\frac{5}{16}$ in a foot.
Copper .... = $\frac{3}{16}$ in a foot.
Bismuth .... = $\frac{5}{32}$ in a foot.

VERNIER SCALE.

The *Vernier* Scale is 11-10ths, divided into 10 equal parts; so that it divides a scale of 10ths into 100ths when the lines meet in the two scales.

COMPARATIVE WEIGHT OF TIMBER IN A GREEN AND SEASONED STATE.

TIMBER.	Weight of a Cub. Ft.		TIMBER.	Weight of a Cub. Ft.	
	Green.	Seasoned.		Green.	Seasoned.
	Lbs. Oz.	Lbs. Oz.		Lbs. Oz.	Lbs. Oz.
Amer. Pine.....	44.12	30 11	Cedar..........	32.	28 4
Ash..........	58. 3	50.	English Oak	71 10	43 8
Beech..........	60.	53 6	Riga Fir......	48.12	35 8

To Compute the Weight of Cast Metal by the Weight of the Pattern.—When the Pattern is of White Pine.—Rule. Multiply the weight of the pattern in pounds by the following multiplier, and the product will give the weight of the casting:

Iron, 14; Brass, 15; Lead, 22; Tin, 14; Zinc, 13.5.

STRENGTH OF MATERIALS.

Bar of Iron. — The average breaking weight of a Bar of Wrought Iron, 1 inch square, is 25 tons; its elasticity is destroyed, however, by about two-fifths of that weight, or 10 tons. It is extended, within the limits of its elasticity, ·000096, or one-ten-thousandth part of an inch for every ton of strain per square inch of sectional area. Hence, the greatest constant load should never exceed one-fifth of its breaking weight, or 5 tons for every square inch of sectional area.

The *lateral strength* of wrought iron, as compared with cast iron, is as 14 to 9. Mr. Barlow finds that wrought iron bars, 3 inches deep, 1½ inches thick, and 33 inches between the supports, will carry 4½ tons.

Bridges. — The greatest extraneous load on a square foot is about 120 pounds.

Floors. — The least load on a square foot is about 160 pounds.

Roofs. — Covered with slate, on a square foot, 51½ pounds.

Beams. — When a beam is supported in the middle and loaded at each end, it will bear the same weight as when supported at both ends and loaded in the middle; that is, each end will bear half the weight.

Cast Iron Beams should not be loaded to more than one-fifth of their ultimate strength.

The strength of similar beams varies inversely as their lengths; that is, if a beam 10 feet long will support 1000 pounds, a similar beam 20 feet long would support only 500 pounds.

A beam supported at one end will sustain only one-fourth part the weight which it would if supported at both ends.

When a beam is fixed at both ends, and loaded in the middle, it will bear one-half more than it will when loose at both ends. When the beam is loaded uniformly throughout it will bear double. When the beam is fixed at both ends, and loaded uniformly, it will bear triple the weight.

In any beam standing obliquely, or in a sloping direction, its strength or strain will be equal to that of a beam of the same breadth, thickness, and material, but only of the length of the horizontal distance between the points of support.

In the construction of beams, it is necessary that their form should be such that they will be equally strong throughout. If a beam be fixed at one end, and loaded at the other, and the breadth uniform throughout its length, then, that the beam may be equally strong throughout, its form must be that of a parabola. This form is generally used in the beams of steam-engines.

When a beam is regularly diminished towards the points that are least strained, so that all the sections are similar figures, whether it be supported at each end and loaded in the middle, or supported in the middle and loaded at each end, the outline should be a cubic parabola.

When a beam is supported at both ends, and is of the same breadth throughout, then, if the load be uniformly distributed throughout the length of the beam, the line bounding the compressed side should be a semi-ellipse.

The same form should be made use of for the *rails* of a wagon-way, where they have to resist the pressure of a load rolling over them.

Similar plates of the same thickness, either supported at the ends or all round, will carry the same weight either uniformly distributed or laid on similar points, whatever be their extent.

The lateral strength of any beam, or bar of wood, stone, metal, etc., is in proportion to its breadth multiplied by its depth^2. In square beams the lateral strengths are in proportion to the cubes of the sides, and in general of like-sided beams as the cubes of the similar sides of the section.

The lateral strength of any beam or bar, one end being fixed in the wall and the other projecting, is inversely as the distance of the weight from the section acted upon; and the strain upon any section is directly as the distance of the weight from that section.

The absolute strength of ropes or bars, pulled lengthwise, is in proportion to the squares of their diameters. All cylindrical or prismatic rods are equally strong in every part, if they are equally thick, but if not they will break where the thickness is least.

The strength of a tube, or hollow cylinder, is to the strength of a solid one as the difference between the fourth powers of the exterior and interior diameters of the tube, divided by the exterior diameter, is to the cube of the diameter of a solid cylinder, — the quantity of matter in each being the same. Hence, from this it will be found, that a hollow cylinder is one-half stronger than a solid one having the same weight of material.

The strength of a column to resist being crushed is directly as the square of the diameter, provided it is not so long as to have a chance of bending. This is true in metals or stone, but in timber the proportion is rather greater than the square.

Models Proportioned to Machines.

The relation of models to machines, as to strength, deserves the particular attention of the mechanic. A model may be perfectly proportioned in all its parts as a model, yet the machine, if constructed in the same proportion, will not be sufficiently strong in every part; hence, particular attention should be paid to the kind of strain the different parts are exposed to; and from the statements which follow, the proper dimensions of the structure may be determined.

If the strain to draw asunder in the model be 1, and if the structure is 8 times larger than the model, then the stress in the structure will be 8^3 equal 512. If the structure is 6 times as large as the model, then the stress on the structure will be 6^3 equal 216, and so on; therefore, the structure will be much less firm than the model; and this the more, as the structure is cube times greater than the model. If we wish to determine the greatest size we can make a machine of which we have a model, we have,

The greatest weight which the beam of the model can bear, divided by the weight which it actually sustains equal a quotient which, when multiplied by the size of the beam in the model, will give the greatest possible size of the same beam in the structure.

Example. — If a beam in the model be 7 inches long, and bear a weight of 4 lbs., but is capable of bearing a weight of 26 lbs., what is the greatest length which we can make the corresponding beam in the structure? Here

$$26 \div 4 = 6{\cdot}5, \qquad \text{therefore, } 6{\cdot}5 \times 7 = 45{\cdot}5 \text{ inches.}$$

The strength to resist crushing increases from a model to a structure in proportion to their size, but, as above, the strain increases as the cubes; wherefore, in this case, also, the model will be stronger than the machine, and the greatest size of the structure will be found by employing the square root of the quotient in the last rule, instead of the quotient itself; thus,

If the greatest weight which the column in a model can bear is 3 cwt., and if it actually bears 28 lbs., then, if the column be 18 inches high, we have

$$\sqrt{\left(\frac{336}{28}\right)} = 3{\cdot}464; \quad \text{wherefore } 3{\cdot}464 \times 18 = 62{\cdot}362$$

inches, the length of the column in the structure.

TABLE OF MANILLA ROPE.

Diam. Ins.	Circ. Ins.	Wt. per foot. lbs.	Breaking load.		Diam. Ins.	Circ. Ins.	Wt. per foot. lbs.	Breaking load.	
			Tons.	lbs.				Tons.	lbs.
·239	¾	·019	·25	560	1·91	6	1·19	11·4	25,536
·318	1	·033	·35	784	2·07	6½	1·39	13·0	29,120
·477	1½	·074	·70	1,568	2·23	7	1·62	14·6	32,704
·636	2	·132	1·21	2,733	2·39	7½	1·86	16·2	36,288
·795	2½	·206	1·92	4,278	2·55	8	2·11	17·8	39,872
·955	3	·297	2·73	6,115	2·86	9	2·67	21·0	47,040
1·11	3½	·404	3·81	8,534	3·18	10	3·30	24·2	54,208
1·27	4	·528	5·16	11,558	3·50	11	3·99	27·4	61,376
1·43	4½	·668	6·60	14,784	3·82	12	4·75	30·6	68,544
1·59	5	·825	8·20	18,368	4·14	13	5·58	33·8	75,712
1·75	5½	·998	9·80	21,952	4·45	14	6·47	37·0	82,880

The strength of Manilla ropes, like that of bar iron, is very variable; and so with hemp ones. The above table supposes an average quality. Ropes of good *Italian* hemp are considerably stronger than Manilla; but their cost excludes them from general use.

The Tarring of ropes is said to lessen their strength; and, when exposed to the weather, their durability also. We believe that the use of it in standing rigging is partly to diminish contraction and expansion by alternate wet and dry weather.

The common rules for finding the strength of rope by multiplying the square of the diameter or circumference by a given coefficient are entirely erroneous.

Prices in Philadelphia, in 1873: Manilla 17 to 18 cents per pound; Italian hemp, 25 cents; American hemp, 15 cents; Sisel hemp, 16 cents; jute (East Indies), 10 cents.

TABLE OF WIRE ROPE, MANUFACTURED BY JOHN A. ROEBLING'S SONS, TRENTON, N. J.

Prices in 1873, 10 per cent. more than table.

ROPE OF 133 WIRES.

Trade Number.	Circumference in inches.	Price per Foot, in cents.	Ultimate Strength in tons of 2000 lbs.	Circumference of Hemp Rope of equivalent strength, in inches.
1	6¾	1 20	74 00	15½
2	6	1 05	65 00	14½
3	5½	91	54 00	13
4	5	78	43 60	12
5	4⅜	65	35 00	10¾
6	4	53	27 20	9½
7	3½	41	20 20	8
8	3⅛	34	16 00	7
9	2¾	28	11 40	6
10	2¼	25	8 64	5
10¼	2	24	5 13	4½
10½	1⅝	23	4 27	4
10¾	1½	22	3 48	3¾

Tiller Rope, ⅝ in diam., 26 cts.

Ropes from No. 8 to No. 10¾ are specially adapted for hoisting-rope.

ROPE OF 49 WIRES.

Trade Number.	Circumference in inches.	Price per Foot, in cents.	Ultimate Strength in tons of 2000 lbs.	Circumference of Hemp Rope of equivalent strength, in inches.
11	4⅝	54	36 00	10¾
12	4¼	47	30 00	10
13	3¾	41	25 00	9½
14	3⅜	35	20 00	8¼
15	3	29	16 00	7¼
16	2⅝	23	12 30	6¼
17	2⅜	18	8 80	5½
18	2⅛	15	7 60	5
19	1⅞	13	5 80	4¾
20	1⅝	11	4 09	4
21	1⅜	9	2 83	3¼
22	1¼	8	2 13	2¾
23	1⅛	7	1 65	2½
24	1	6½	1 38	2¼
25	⅞	6	1 03	2
26	¾	5½	0 81	1¾
27	⅝	5	0 56	1½
27½	½	4		
28		3	Large Sash Cord.	
29		2	Small " "	

Notes on the Use of Wire Rope, by Mr. Roebling.

Two kinds of wire rope are manufactured; the larger sizes, as also the most pliable, are composed of 133 wires, and are generally used for hoisting or running rope. Those of 49 wires are stiffer, and are better adapted for standing rope, guys, and rigging.

For safe working load, allow $\frac{1}{5}$ to $\frac{1}{7}$ of ultimate strength, according to speed and vibration. When substituting Wire Rope for hemp rope, it is good economy to allow for the former the same rate per foot run which experience has approved of for the latter.

Wire Rope is as pliable as new hemp rope of the same strength; the former will therefore run over the same sized sheaves and pulleys which are used for the latter. But the greater the diameter of the sheaves, pulleys, or drums, the longer Wire Rope will last. In the construction of machinery for Wire Rope it will be found good economy to make the drums and sheaves as large as possible. The size of drum is as follows: The same figure which expresses the circumference in inches in the second column of the table is also the minimum diameter of drum in feet; doubling that figure will give the maximum. The diameter of drum should be no less than the minimum, nor is it necessary to exceed the maximum. As an example, take a No. 4 rope, circumference 5 inches; therefore the minimum diameter of drum is 5 feet, and the maximum 10 feet. Or a No. 10¼ rope, circumference 2 inches; therefore minimum diameter is 2 feet; and maximum 4 feet. A smaller diameter of drum may answer, but the short bending will result in a much more rapid wear. In most cases the Rope will wear twice as long on a maximum diameter as on a minimum.

Experience has also demonstrated that the wear increases with the speed. It is better to increase the load than the speed.

Wire Rope is manufactured either with a wire or hemp centre. The latter is more pliable than the former, and will wear better where there is short bending.

Wire Rope must *not* be coiled or uncoiled like hemp rope. When mounted on a reel the latter should be turned on a spindle to pay off the rope. When forwarded in a coil without reel, roll it over the ground like a wheel, and run off the rope in that way. All untwisting must be avoided.

To preserve Wire Rope apply raw linseed oil with a piece of sheepskin, wool inside; or mix the oil with equal parts of Spanish brown and lampblack.

To preserve Wire Rope under water or under ground, take mineral or vegetable tar, add 1 bushel of fresh slacked lime to 1 barrel of tar, (which will neutralize the acid,) and boil it well, then saturate the rope with the boiling tar.

The grooves of cast-iron pulleys and sheaves should be filled with well-seasoned blocks of hard wood, set *on end*, to be renewed when worn out. This end wood will save the rope and increase adhesion. The small pulleys or rollers which support the ropes on inclined planes should be constructed on the same plan. When large sheaves run with a very great velocity, the grooves must be lined either with leather set on end, with cork, or with India rubber. This is done in the case of all sheaves used in the *transmission of power* between distant points by means of ropes, which frequently run at the rate of 4000 feet per minute. Rope ¾ inch diameter will transmit 100 horse power to a great distance.

WEIGHT AND STRENGTH OF IRON CHAINS.

The links of ordinary iron chains are usually made as short as is consistent with easy play, in order that they may not become bent when wound around drums, sheaves, etc.; and that they may be more easily handled in slinging large blocks of stone, etc.

When so made, their weight per foot run is quite approximately 3½ times that of a single bar of the round iron of which they are composed. Since each link consists of two thicknesses of bar, it might be supposed that a chain would possess about double the strength of a single bar; but the strength of the bar becomes reduced about 3/10, by being formed into links; so that the chain really has but about 7/10 of the strength of two bars. As a thick bar of iron will not sustain as heavy a load in proportion as a thinner one, so of course stout chains are proportionably weaker than slighter ones. In the following table, 20 tons *per square inch* is assumed as the average breaking strain of a single straight bar of ordinary rolled iron, 1 inch in diameter, or 1 inch square; 19 tons, from 1 to 2 inches; and 18 tons, from 2 to 3 inches. Deducting 3/10 from each of these, we have as the breaking strain of the two bars composing each link, as follows: 14 tons *per square inch*, up to 1 inch diameter; 13·3 tons, from 1 to 2 inches; and 12·6 tons, from 2 to 3 inches diameter; and upon these assumptions the table is based.*

TABLE OF STRENGTH OF CHAINS. (Original.)

Chains of superior iron will require ¼ to ⅓ more to break them.

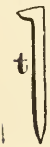
Diam. of rod of which the links are made.	Weight of chain per ft. run.	Breaking strain of the chain.		Diam. of rod of which the links are made	Weight of chain per ft. run.	Breaking strain of the obain.	
Ins.	Pds.	Pds.	Tons.	Ins.	Pds.	Pds.	Tons.
3/16	·325	1,731	·773	1	9·26	49,280	22·00
1/4	·579	3,069	1·37	1⅛	11·7	59,226	26·44
5/16	·904	4,794	2·14	1¼	14·5	73,114	32·64
3/8	1·30	6,922	3·09	1⅜	17·5	88,301	39·42
7/16	1·78	9,408	4·20	1½	20·8	105,280	47·00
1/2	2·31	12,320	5·50	1⅝	24·4	123,514	55·14
9/16	2·93	15,590	6·96	1¾	28·4	143,293	63·97
5/8	3·62	19,219	8·58	1⅞	32·6	164,505	73·44
11/16	4·38	23,274	10·39	2	37·0	187,152	83·55
3/4	5·21	27,687	12·36	2¼	46·9	224,448	100·2
13/16	6·11	32,301	14·42	2½	57·9	277,088	123·7
7/8	7·10	37,632	16·80	2¾	70·0	335,328	149·7
15/16	8·14	43,277	19·32	3	83·3	398,944	178·1

* Price in 1873 of chains, about 10 cents per pound for ⅜; 7¼ for ⅝; 6 for ⅞; 5½ for 1⅛.

WEIGHT OF RAILROAD SPIKES.[*]

The hook-headed spikes *t*, commonly used for confining rails to the cross-ties, vary within the limits of the following table; the lightest ones for light rails on short local branches; and the heaviest ones for heavy rails on first-class roads. The table is from the Phœnix Iron Company of Philadelphia. The spikes are sold in kegs usually of 150 pounds. For the weight of spikes of larger dimensions, we may near enough take that of a square bar of the same length. What is saved at the point, suffices for the addition at the head.

Fig.43.



Size in ins.	No. per keg of 150 lbs.	No. per lb.	Size in ins.	No. per keg of 150 lbs.	No. per lb.
Length. Side.			Length. Side.		
$4\frac{1}{2} \times \frac{7}{16}$	526	3·5	$5\frac{1}{2} \times \frac{1}{2}$	350	2·33
$4\frac{1}{2} \times \frac{1}{2}$	400	2·66	$5\frac{1}{2} \times \frac{9}{16}$	289	1·93
$5 \times \frac{3}{8}$	705	4·7	$5\frac{1}{2} \times \frac{5}{8}$	218	1·46
$5 \times \frac{7}{16}$	488	3·25	$6 \times \frac{1}{2}$	310	2·07
$5 \times \frac{1}{2}$	390	2·6	$6 \times \frac{9}{16}$	262	1·75
$5 \times \frac{9}{16}$	295	1·97	$6 \times \frac{5}{8}$	196	1·30
$5 \times \frac{5}{8}$	257	1·71			

A size in very common use is $5\frac{1}{2} \times \frac{9}{16}$, which weighs about $\frac{1}{2}$ pound per spike. A mile of single track road, with 2,112 cross-ties, $2\frac{1}{2}$ feet apart from centre to centre, and with rails of the ordinary length of 24 feet, or 10 ties to a rail, thus having 440 rail-joints per mile, with 4 spikes to each tie, except at the rail-joints, at each of which there will be 4 spikes,[†] will require, at a neat calculation, 9,328 spikes.

But an allowance must be made for rail guards at road-crossings, which we may assume to be 24 feet wide, or the length of a rail. A guard will usually consist of 4 extra rails for protecting the track rails, and spiked to the 11 ties by which said track rails are sustained. Consequently, such a crossing requires $11 \times 8 = 88$ spikes. For turnouts, sidings, loss, etc., we may roughly average 584[‡] spikes more per mile; thus making in all (if we assume one road-crossing per mile) $9328 + 88 + 584 = 10{,}000$ spikes per mile, or 5000 pounds, or $33\frac{1}{3}$ kegs of 150 pounds.

Adhesion of Spikes. — Professor W. R. Johnson found that a plain spike ·375, or $\frac{3}{8}$ inch square, driven $3\frac{3}{8}$ inches into seasoned Jersey yellow pine, or unseasoned chestnut, required about 2000 pounds force to extract it; from seasoned white oak, about 4000; and from well-seasoned locust, about 6000 pounds. Bevan found that a 6-penny nail, driven one inch, required the following forces to extract it: Seasoned beech, 667 pounds; oak, 507; elm, 327; pine, 187.

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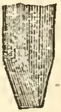
[*] The price of spikes, and of cut nails, in Philadelphia, in 1873, about 5 cents per pound. Rivets 16 cents.

[†] This supposes the joint and chair to rest upon a tie; but when long chairs are used, with a view of placing the rail-joint between two ties laid near each other, there will be 8 spikes to a joint; or 1,760 per mile more than above; equal to 880 pounds; making in all, per mile single track, say 12,000 spikes, or 6,000 pounds, or 40 kegs.

[‡] This allows that turnouts and sidings amount to about 1 mile of extra track on 15 miles of road.

Recent careful experiments in Hanover, Germany, by Engineer Funk, give from 2465 to 3940 pounds (mean of many experiments, about 3000 pounds) as the force necessary to extract a plain $\frac{1}{2}$ inch square iron spike, 6 inches long, wedge-pointed for one inch (twice the thickness of the spike), and driven $4\frac{1}{2}$ inches into *white* or *yellow pine*. When driven 5 inches, the force required was about $\frac{1}{10}$ part greater. Similar spikes, $\frac{9}{16}$ inch square, 7 inches long, driven 6 inches deep, required from 3700 to 6745 pounds to extract them from pine; the mean of the results being 4873 pounds. In all cases *about twice as much force was required to extract them from oak.* The spikes were all driven *across* the grain of the wood. Experience shows that when driven *with* the grain, spikes or nails do not hold with much more than half as much force.

Fig. 44.



Jagged spikes, or twisted ones (like an auger), or those which were either swelled or diminished near the middle of their length, all proved inferior to plain square ones. When the length of the wedge point was increased to 4 times the thickness of the spike, the resistance to drawing out was a trifle less.

When the length of the spike is fixed, there is probably no better shape than the plain square cross-section, with a wedge point twice as long as the width of the spike, as per Fig. 44.

Boards of oak or pine, nailed together by from 4 to 16 tenpenny common cut nails, and then pulled apart in a direction lengthwise of the boards, and across the nails, tending to break the latter in two by a shearing action, averaged about 300 to 400 pounds per nail to separate them; as the result of many trials.

WEIGHT OF NAILS.*

Name.	Length. Inches.	No. per lb.	Name.	Length. Inches.	No. per lb.
3 penny	1	557	8 penny	$2\frac{1}{2}$	101
4 "	$1\frac{1}{4}$	353	10 "	$2\frac{3}{4}$	68
5 "	$1\frac{3}{4}$	232	12 "	3	54
6 "	2	175	20 "	$3\frac{1}{2}$	34
7 "	$2\frac{1}{4}$	141			

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* Price in Philadelphia, 1873, about 5 cents per pound. Roofing nails of tinned iron, 12 cents. Copper nails, 50 cents.

The sizes and weights vary considerably with different makers. The above are machine-made, or CUT NAILS, in distinction to the WROUGHT NAILS made by the blacksmith.

A TABLE

Showing the Weight or Pressure a beam of Cast Iron, 1 *inch in breadth, will sustain, without destroying its elastic force, when it is supported at each end, and loaded in the middle of its length, and also the deflection in the middle which that weight will produce.* By Mr. Hodgkinson, Manchester.

Length.	6 Feet.		7 Feet.		8 Feet.		9 Feet.		10 Feet.	
Depth in in.	Weight in lbs.	Defl. in in.	Weight in lbs.	Defl. in in.	Weight in lbs.	Defl. in in.	Weight in lbs.	Defl. in in.	Weight in lbs.	Defl. in in.
3	1278	·24	1089	·33	954	·426	855	·54	765	·66
3½	1739	·205	1482	·28	1298	·365	1164	·46	1041	·57
4	2272	·18	1936	·245	1700	·32	1520	·405	1360	·5
4½	2875	·16	2450	·217	2146	·284	1924	·36	1721	·443
5	3560	·144	3050	·196	2650	·256	2375	·32	2125	·4
6	5112	·12	4356	·163	3816	·213	3420	·27	3060	·33
7	6958	·103	5929	·14	5194	·183	4655	·23	4165	·29
8	9088	·09	7744	·123	6784	·16	6080	·203	5440	·25
9			9801	·109	8586	·142	7695	·18	6885	22
10			12100	·098	10600	·128	9500	·162	8500	·2
11					12826	·117	11495	·15	10285	·182
12					15264	·107	13680	·135	12240	·17
13							16100	·125	14400	·154
14							18600	·115	16700	·143
	12 Feet.		14 Feet.		16 Feet.		18 Feet.		20 Feet.	
6	2548	·48	2184	·65	1912	·85	1699	1·08	1530	1·34
7	3471	·41	2975	·58	2603	·73	2314	·93	2082	1·14
8	4532	·36	3884	·49	3396	·64	3020	·81	2720	1·00
9	5733	·32	4914	·44	4302	·57	3825	·72	3438	·89
10	7083	·28	6071	·39	5312	·51	4722	·64	4250	·8
11	8570	·26	7346	·36	6428	·47	5714	·59	5142	·73
12	10192	·24	8736	·33	7648	·43	6796	·54	6120	·67
13	11971	·22	10260	·31	8978	·39	7980	·49	7182	·61
14	13883	·21	11900	·28	10412	·36	9255	·46	8330	·57
15	15937	·19	13660	·26	11952	·34	10624	·43	9562	·53
16	18128	·18	15536	·24	13584	·32	12080	·40	10880	·5
17	20500	·17	17500	·23	15353	·30	13647	·38	12282	·47
18	22932	·16	19656	·21	17208	·28	15700	·36	13752	·44

NOTE.—This table shows the greatest weight that ever ought to be laid upon a beam for permanent load; and if there be any liability to jerks, etc., ample allowance must be made; also, the weight of the beam itself must be included. [*See Tables of Cast Iron.*]

To find the Weight of a Cast Iron Beam of given Dimensions.

Rule.—Multiply the sectional area in inches by the length in feet, and by 3·2, the product equal the weight in pounds.

Example.—Required the weight of a uniform rectangular beam of cast iron, 16 feet in length, 11 inches in breadth, and 1½ inch in thickness.

$$11 \times 1{\cdot}5 \times 16 \times 3{\cdot}2 = 844{\cdot}8 \text{ pounds.}$$

Resistance of Bodies to Flexure by Vertical Pressure.

When a piece of *timber* is employed as a column or support, its tendency to yielding by compression is different according to the proportion between its length and area of its cross section; and supposing the form that of a cylinder whose length is less than seven or eight times its diameter, it is impossible to bend it by any force applied longitudinally, as it will be destroyed by splitting before that bending can take place; but when the length exceeds this, the column will bend under a certain load, and be ultimately destroyed by a similar kind of action to that which has place in the transverse strain. Columns of *cast iron* and of other bodies are also similarly circumstanced.

When the length of a *cast iron column* with flat ends equals about thirty times its diameter, fracture will be produced wholly by bending of the material. When of less length, fracture takes place partly by crushing and partly by bending. But, when the column is enlarged in the middle of its length from one and a half to twice its diameter at the ends, by being cast hollow, the strength is greater by one-seventh than in a solid column containing the same quantity of material.

To determine the Dimensions of a Support or Column to bear, without sensible Curvature, a given Pressure in the Direction of its Axis.

Rule.—Multiply the pressure to be supported in pounds by the square of the column's length in feet, and divide the product by twenty times the tabular value of E; and the quotient will be equal to the breadth multiplied by the cube of the least thickness, both being expressed in inches.

Note 1.—When the *pillar or support* is a square, its side will be the fourth root of the quotient.

Note 2.—If the pillar or column be a cylinder, multiply the tabular value of E by 12, and the fourth root of the quotient equal the diameter.

Example 1.—What should be the least dimensions of an oak support, to bear a weight of 2240 pounds, without sensible flexure, its breadth being 3 inches, and its length 5 feet?

$$\text{Tabular value of } E = 105,$$
$$\text{and } \frac{2240 \times 5^2}{20 \times 105 \times 3} = \sqrt[3]{8 \cdot 888} = 2 \cdot 05 \text{ inches.}$$

Example 2.—Required the side of a square piece of Riga fir, 9 feet in length, to bear a permanent weight of 6000 pounds.

$$\text{Tabular value of } E = 96,$$
$$\text{and } \frac{6000 \times 9^2}{20 \times 96} = \sqrt[4]{253} = 4 \text{ inches nearly.}$$

Elasticity of Torsion, or Resistance of Bodies to Twisting.

The angle of flexure by torsion is as the length and extensibility of the body directly and inversely as the diameter; hence the length of a bar or shaft being given, the power, and the leverage the power acts with, being known, and also the number of degrees of torsion that will not affect the action of the machine, to determine the diameter in cast iron with a given angle of flexure.

Rule.—Multiply the power in pounds by the length of the shaft in feet, and by the leverage in feet; divide the product by fifty-five times the number of degrees in the angle of torsion; and the fourth root of the quotient equal the shaft's diameter in inches.

Example.—Required the diameters for a series of shafts 35 feet in length, and to transmit a power equal to 1245 pounds, acting at the circumference of a wheel $2\frac{1}{2}$ feet radius, so that the twist of the shafts on the application of the power may not exceed one degree.

$$\frac{1245 \times 35 \times 2 \cdot 5}{55 \times 1} = \sqrt[4]{1981} = 6 \cdot 67 \text{ inches in diameter.}$$

To determine the Side of a Square Shaft to resist Torsion with a given Flexure.

Rule.—Multiply the power in pounds by the leverage it acts with in feet, and also by the length of the shaft in feet; divide this product by 92·5 times the angle of flexure in degrees, and the square root of the quotient equals the area of the shaft in inches.

Example.—Suppose the length of a shaft to be 12 feet, and to be driven by a power equal to 700 pounds, acting at 1 foot from the centre of the shaft—required the area of cross section, so that it may not exceed 1 degree of flexure.

$$\frac{700 \times 1 \times 12}{92{\cdot}5 \times 1} = \sqrt[2]{90{\cdot}8} = 9{\cdot}53 \text{ inches.}$$

Relative Strength of Bodies to resist Torsion, Lead being 1.

Tin	1·4	Gun Metal	5·0	English Iron	10·1
Copper	4·3	Cast Iron	9·0	Blistered Steel	16·6
Yellow Brass	4·6	Swedish Iron	9·5	Shear Steel	17·0

STRENGTH OF BEAMS.

[*From Lowndes' Engineer's Hand-book,—Liverpool,* 1860.]

Solid, Rectangular, and Round—To find their Strength.

Square and rectangular.

$$\frac{(\text{Depth ins.})^2 \times \text{Thickness ins.}}{\text{Length, ft.}} \times \text{Tabular No.} = \text{Breaking weight, tons.}$$

Round.

$$\frac{(\text{Diameter ins.})^3}{\text{Length in ft.}} \times \text{Tabular No.} = \text{Breaking weight, tons.}$$

Hollow.

$$\frac{(\text{Outside dia. ins.})^3 - (\text{Inside dia. ins.})}{\text{Length, ft.}} \times \text{Tabular No.} = \text{Breaking weight, tons.}$$

Thickness not exceeding	1 inch for iron. 3 ins. for wood.	2 ins. for iron. 6 ins. for wood.	3 ins. for iron. 12 ins. for wood.

Square and Rectangular.

Cast and Wrought Iron	·1	·85	·7
Teak and greenheart	·36	·32	·26
Pitch pine, and Canadian oak	·25	·22	·18
Fir, red pine, and English oak	·18	·16	·13

Round.

Cast and Wrought Iron	·8	·68	·56
Teak and greenheart...	·28	·25	·2
Fir and English oak...	·14	·125	·1

To find the Breaking Weight in lbs. use the Tabular No. below.

Thickness not exceeding	1 inch for iron. 3 ins. for wood.	2 ins. for iron. 6 ins. for wood.	3 ins. for iron. 12 ins. for wood.
Square and Rectangular.			
Iron........................	2240	1900	1570
Teak........................	800	710	570
Fir and oak...............	400	355	285
Round.			
Iron........................	1800	1570	1260
Teak........................	640	570	460
Fir and oak...............	320	285	230

Though wrought and cast iron are represented in these rules as of equal strength, it should be observed that while a cast iron bar 1 inch × 1 inch × 1 foot 0 inch long, of average quality, will break with one ton, a similar bar of wrought iron only loses its elasticity, and deflects $\frac{1}{16}$ th of an inch, yet as it can only carry a further weight by destroying its shape and increasing the deflection, it is best to calculate on the above basis:

A wrought iron bar 1 in. × 1 in. × 1 ft. 0 in. long	deflects	$\frac{1}{16}$	with	1 ton.
		$\frac{1}{8}$	"	$1\frac{1}{4}$ "
		$2\frac{1}{2}$	"	$2\frac{1}{4}$ "

The above rule gives the weight that will break the beam if put on the middle. If the weight is laid equally all over, it would require double the weight to break it.

A beam should not be loaded with more than $\frac{1}{3}$ of the breaking weight in any case, and as a general rule not with more than $\frac{1}{4}$; for purposes of machinery, not with more than $\frac{1}{6}$ to $\frac{1}{10}$, depending on circumstances.

To find the proper size for any given purpose.

Rectangular.

$$\frac{\text{Weight} \times \text{Length ft.}}{\text{Tabular No.}} \times 3 \text{ or } 4 \text{ or } 6, \text{ etc., according to circumstances}$$

$= \text{B D}^2$ ins.

Round.

$\sqrt[3]{\frac{\text{Weight} \times \text{Length ft.}}{\text{Tabular No.}} \times 3 \text{ or } 4 \text{ or } 6\text{, etc., according to circumstances}} = \text{Diam. ins.}$

SOLID COLUMNS.

Fail by crushing with length under.............	5	diameters.
Principally by crushing from.....................	5 to 15	"
Partly by crushing, partly by bending, from.	15 to 25	"
Altogether by bending above.........	25	"

Cast iron of average quality is crushed with.....	49	tons per sq. in.
Wrought iron of average quality is crushed with	16	" "
Wrought iron is permanently injured with.......	12	" "
Oak wrought is crushed with........................	4	" "
Deal wrought is crushed with.......................	2	" "

The comparative strength of different columns, of different lengths, will be seen very clearly from the following table derived from experiments by Mr. Hodgkinson:

Wrought Iron Bars.		Proportion of Length to Thickness.	Gave way with
Square.	Length.		
ins.	ft. ins.		
1 × 1	7½	7½ to 1	21·7 tons per sq. inch.
"	1 3	15 to 1	15·4 " "
"	2 6	30 to 1	11·3 " "
"	5 0	60 to 1	7·5 " "
"	7 6	90 to 1	4·3 " "
½ × ½	5 0	120 to 1	2·5 " "
"	7 6	180 to 1	1· " "

To find the Strength of any Wrought Iron Column with Square Ends.

Area of column sq. inches × tons per inch corresponding to proportion of length, as per table above = Breaking weight, tons.

If the ends are rounded, divide the final result by 3 to find the breaking weight.

In columns of oblong section, the narrowest side must always be taken in calculating the proportion of height to width.

To find the Strength of Round Columns exceeding 25 Diameters in Length. (Mr. Hodgkinson's Rule.)

$$\frac{(\text{Diameter, ins.})^{3.6}}{(\text{Length, ft.})^{1.7}} \times \text{Tabular No.} = \text{Breaking weight, tons.}$$

	Square Ends.	Rounded or Movable Ends.
Wrought iron..................	77	26
Cast iron..........................	44	15
Dantzic oak.....................	4·5	1.7
Red deal..........................	3·3	1·2

A column should not be loaded with more than $\frac{1}{3}$ of the breaking weight in any case, and as a general rule, not with more than $\frac{1}{4}$; for purposes of machinery, not with more than $\frac{1}{6}$ to $\frac{1}{10}$, according to circumstances.

TABLES OF POWERS FOR THE DIAMETERS AND LENGTHS OF COLUMNS.

Diameter.	3·6 Power.	Diameter.	3·6 Power.	Length.	1·7 Power.
1 in.	1·	7 in.	1102·04	1	1·
¼	2·23	¼	1251·	2	3·25
½	4·3	½	1413·3	3	6·47
¾	7·5	¾	1590·3	4	10·556
2	12·1	8	1782·9	5	15·426
¼	18·5	¼	1991·7	6	21·031
½	27·	½	2217·7	7	27·332
¾	38·16	¾	2461·7	8	34·297
3	52·2	9	2724·4	9	41·9
¼	69·63	¼	3006·85	10	50·119
½	90·9	½	3309·8	11	58·934
¾	116·55	¾	3634·3	12	68·329
4	147·	10	3981·07	13	78·289
¼	182·9	¼	4351·2	14	88·8
½	224·68	½	4745·5	15	99·85
¾	272·96	¾	5165·	16	111·43
5	328·3	11	5610·7	17	123·53
¼	391·36	¼	6083·4	18	136·13
½	462·71	½	6584·3	19	149·24
¾	543·01	¾	7114·4	20	162·84
6	632·91	12	7674·5	21	176·92
¼	733·11			22	191·48
½	844·28			23	206·51
¾	967·15			24	222·

HOLLOW COLUMNS.

Hollow columns fail principally by crushing, provided the length does not exceed 25 diameters; indeed, the length does not appear to affect the strength much till it exceeds 50 diameters.

The comparative strength of different forms and of different thicknesses will appear so distinctly from the experiments below, made by Mr. Hodgkinson, that no difficulty will be found in ascertaining the strength due to any size or form of column that may be required.

SQUARE COLUMNS OF PLATE IRON RIVETED.

Columns 10 feet 0 inches long.

Size.	Thickness.	Proportion of Thickness to Width.	Proportion of Length to Width.	Break'g weight Tons per sq. in. of Section.
4 in. × 4 in.	·03	$\frac{1}{133}$	30 to 1	4·9
"	·06	$\frac{1}{66}$	"	8·6
"	·1	$\frac{1}{40}$	"	10·
"	·2	$\frac{1}{20}$	"	12·
8 in. × 8 in.	·06	$\frac{1}{133}$	15 to 1	6·
"	·14	$\frac{1}{60}$	"	9·
"	·22	$\frac{1}{36}$	"	11·5
"	·25	$\frac{1}{32}$	"	12·

Column 8 feet 0 inches long.

18 × 18	·5	$\frac{1}{30}$ practically	5·4 to 1	13·6

Column 10 feet 0 inches long, with cells.

8 in. × 8 in.	·06	$\frac{1}{66}$ of width of cells	15 to 1	8·6

To find the strength of any Hollow Wrought Iron Column.

Sec. area. sq. ins. × Tons per inch, corresponding to the proportions of length and thickness to width as per tables = Breaking weight, tons.

COLUMNS OF OBLONG SECTION.

The strength of these may be ascertained by the same rule as that of square columns. The smallest width being taken in calculating the proportion of height to width, while the longest side must be taken into consideration in calculating the proportion of thickness to width.

Column 10 feet 0 inches long.

Size.	Thickness.	Proportion of Thickness to greatest Width.	Proportion of Length to least Width.	Actual Breaking weight Tons per sq. in. of Section.
8 in. × 4 in.	·06	$\frac{1}{133}$	30 to 1	6·78

ROUND COLUMNS OF PLATE IRON RIVETED.

Columns 10 feet 0 inches long.					*Same Columns Reduced in Length.*	
					Breaking Weights. Tons per square inch.	
Diameter.	Thickness.	Proportion of thickness to Diameter.	Proportion of length to Diameter.	Breaking Weight. Tons per sq. inch.	5 ft. 0 in. long.	2 ft. 6 in. long.
$1\frac{1}{2}$	·1	$\frac{1}{15}$	80 to 1	6·5	13·9	5·8
2	·1	$\frac{1}{20}$	60 to 1	10·35	14·8	16·5
$2\frac{1}{2}$	·1	$\frac{1}{25}$	48 to 1	13·3	15·6	16·3
$2\frac{1}{2}$	·24	$\frac{1}{11}$	48 to 1	9·6	15·6	16·
$2\frac{1}{2}$	·21	$\frac{1}{12}$	48 to 1	9·9	13·	17·
3	·15	$\frac{1}{26}$	40 to 1	12·36	13·	16·5
4	·15	$\frac{1}{26}$	30 to 1	12·34	13·	
6	·1	$\frac{1}{60}$	20 to 1	15·	17·	18·6
6	·13	$\frac{1}{46}$	20 to 1	18·6		

It would seem from this that a thickness of $\frac{1}{48}$, or $\frac{1}{4}$ inch in thickness for every foot in diameter is a good proportion for this kind of column.

It will be seen from these experiments, that it is the proportion of thickness to the width of cell which regulates the strength within certain limits of height.

And that a thickness of $\frac{1}{30}$ or $\frac{1}{8}$ inch for every 4 inches in width will give the highest result practicable for square columns.

CRANE.

The strains on the principal parts can be ascertained with great ease in the following manner—the strength being proportioned accordingly.

To find the Strain on the Post.

$$\frac{\text{Weight suspended, tons} \times \text{Projection, feet}}{\text{Height of post above ground, feet}} = \text{Strain on top of post, tons.}$$

The post can then be calculated as a beam, twice as long as this height from ground, with twice the weight on the middle. [*See Beams.*]

COLD WATER PUMP.

Usually $\frac{1}{4}$ of cylinder diameter when the stroke is $\frac{1}{2}$ that of piston.
$\frac{1}{3}$ " " $\frac{1}{4}$ "

To find the proper size, under any circumstances, capable of supplying twice the quantity ordinarily used for injection.

$$\frac{\text{Cub. ft. water per hour used in cylinder in form of steam}}{\text{Stroke of pump, ft.} \times \text{strokes per minute}} = \text{Area}$$
of pump in square feet.

PEDESTAL — BRACKET.

Pedestal.

Good proportions.

Thickness of cover......	·4	of diameter of bearing.	
" of sole plate	·3	" "	
Diameter of bolts.......	·25	" "	if 2.
" "	·18	" "	if there are 4.

Distance between bolts twice diameter of bearing.

Bracket.

Solid. Metal round brass equal to $\frac{1}{2}$ diameter of bearing.
General thickness web, etc., equal to $\frac{1}{4}$ diameter of bearing.
With Feathers. Width at lightest equal to diameter of bearing.
Thickness equal to $\frac{1}{6}$ " "

FRICTION.

From Mr. Rennie's Experiments.

The friction of metal on metal, without unguents,
May be taken at $\frac{1}{6}$ of the weight up to 40 lbs. per square inch.
" $\frac{1}{5}$ " " 100 "
Brass on cast iron $\frac{1}{4}$ " " 800 "
Wrought on cast iron $\frac{1}{3}$ " " 500 "
With tallow at $\frac{1}{10}$ of the weight.
" olive oil at $\frac{1}{13}$ "
800 lbs. per inch forces out the oil.
Friction of journals under ordinary circumstances $\frac{1}{30}$ of weight.
" well oiled, sometimes only $\frac{1}{60}$ "

CENTRIFUGAL FORCE.

$$\frac{(\text{Revolutions per min.})^2 \times \text{dia. in ft.} \times \text{weight}}{5870} = \text{Centrifugal force}$$
in terms of weight.

WEIGHTS AND VOLUMES OF VARIOUS SUBSTANCES IN ORDINARY USE.

SUBSTANCES.	Cubic Foot.	Cubic Inches	SUBSTANCES.	Cubic Foot.	Cubic Feet in a Ton.
METALS.	Lbs.	Lbs.	WOODS.	Lbs.	
Brass. { copper 67.	488.75	.2829	Pine, yellow	33.812	66.248
" { zinc 33. }			Spruce	31.25	71.68
" gun metal	543.75	.3147	Walnut, bl'k, dry	31.25	71.68
" sheets	513.6	.297	Willow	36.562	61.265
" wire	524.16	.3033	" dry	30.375	73.744
Copper, cast	547.25	.3179			
" plates	543.625	.3167	MISCELLANEOUS.		
Iron, cast	450.437	.2607			
" gun metal	466.5	.27	Air	.075291	—
" heavy forging	479.5	.2775	Basalt, mean	175.	12.8
" plates	481.5	.2787	Brick, fire	137.526	16.284
" wrought bars.	486.75	.2816	" mean	102.	21.961
Lead, cast	709.5	.4106	Coal, anthracite. {	89.75	24.958
" rolled	711.75	.4119		102.5	21.854
Mercury, 60°	848.7487	.491174	" bitum. mean	80.	28.
Steel, plates	487.75	.2823	" Cannel	94.875	23.609
" soft	489.562	.2833	" Cumberland	84.687	26.451
Tin	455.687	.2637	" Welsh, mean	81.25	27.569
Zinc, cast	428.812	.2482	Coke	62.5	35.84
" rolled	440.437	.2601	Cotton, bale, mean	14.5	154.48
			" " pressd {	20.	114.
WOODS.		Cub. Ft.		25.	89.6
		in a ton.	Earth, clay	120.625	18.569
Ash	52.812	42.414	" com'n soil	137.125	16.335
Bay	51.375	43.601	" " gravel	109.312	20.49
Cork	15.	149.333	" dry, sand	120.	18.667
Cedar	35.062	63.886	" loose	93.75	23.893
Chestnut	38.125	58.754	" moist, sand	128.125	17.482
Hickory, pig nut	49.5	45.252	" mould	128.125	17.482
" shell-bark	43.125	51.942	" mud	101.875	21.987
Lignumvitæ	83.312	26.886	" with gravel	126.25	17.742
Logwood	57.062	39.255	Granite, Quincy	165.75	13.514
Mahog. Hondur's {	35.	64.	" Susqueh'na	169.	13.254
	66.437	33.714	Hay, bale	9.525	23.517
Oak, Canadian	54.5	41.101	" pressed	25.	89.6
" English	58.25	38.455	India rubber	56.437	39.60
" live, seasoned	66.75	33.558	" vulcanized	—	—
" white, dry	53.75	41.674	Limestone	197.25	11.355
" " upland	42.937	52.169	Marble, mean	167.875	13.343
Pine, pitch	41.25	54.303	Mortar, dry, mean	97.98	22.862
" red	36.875	60.745	Water, fresh	62.5	35.84
" white	34.625	64.693	" salt	64.125	34.931
" well seasoned	29.562	75.773	Steam	.036747	—

WEIGHT OF ONE FOOT OF FLAT BAR IRON.

If a bar of iron be thicker than contained in the table, add together the weight of two numbers, or treble the weight of one number. Wanted the weight of 1 foot of bar iron, 4 inches broad and 2 1-4 inches thick. Opposite 4 and under 1 is 13.364, which doubled is 26.728; add the weight of 1-4th (3.341), equal 30.069 lbs.

Breadth in inches.	THICKNESS IN PARTS OF AN INCH.								
	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1 in.
1	.835	1.044	1.253	1.461	1.670	2.088	2.506	2.923	3.340
1⅛	.939	1.174	1.409	1.644	1.878	2.348	2.818	3.287	3.756
1¼	1.044	1.305	1.566	1.826	2.088	2.609	3.132	3.653	4.176
1⅜	1.148	1.435	1.722	2.009	2.296	2.870	3.444	4.018	4.592
1½	1.252	1.566	1.879	2.192	2.504	3.131	3.758	4.384	5.008
1⅝	1.358	1.696	2.035	2.374	2.716	3.392	4.070	4.749	5.432
1¾	1.462	1.827	2.192	2.557	2.924	3.653	4.384	5.114	5.848
1⅞	1.566	1.957	2.348	2.740	3.132	3.914	4.696	5.479	6.264
2	1.671	2.088	2.505	2.922	3.342	4.175	5.010	5.845	6.684
2⅛	1.775	2.218	2.662	3.105	3.550	4.435	5.324	6.210	7.100
2¼	1.880	2.348	2.818	3.288	3.760	4.696	5.636	6.575	7.520
2⅜	1.984	2.479	2.975	3.470	3.968	4.957	5.950	6.941	7.936
2½	2.088	2.609	3.131	3.653	4.176	5.218	6.262	7.306	8.352
2⅝	2.193	2.740	3.288	3.836	4.386	5.479	6.576	7.671	8.772
2¾	2.297	2.870	3.444	4.018	4.594	5.740	6.888	8.036	9.188
2⅞	2.402	3.001	3.601	4.201	4.804	6.001	7.202	8.402	9.608
3	2.506	3.131	3.758	4.384	5.012	6.262	7.516	8.767	10.024
3¼	2.715	3.392	4.071	4.749	5.430	6.784	8.142	9.498	10.860
3½	2.923	3.653	4.384	5.114	5 846	7.306	8.768	10.228	11.692
3¾	3.132	3.914	4.697	5.479	6.264	7.828	9.394	10.959	12.528
4	3.341	4.175	5.010	5.845	6.682	8.350	10.020	11.690	13.364
4¼	3.549	4.436	5.323	6.210	7.098	8.871	10.646	12.421	14.196
4½	3.758	4.697	5.636	6.575	7.516	9.393	11.272	13.151	15.032
4¾	3.966	4.958	5.949	6.941	7.932	9.915	11.898	13.881	15.864
5	4.175	5.219	6.263	7.306	8.350	10.437	12.526	14.612	16.700
5¼	4.384	5.479	6.576	7.671	8.768	10.958	13.152	15.343	17.536
5½	4.593	5.741	6.889	8.037	9.186	11.480	13.778	16.073	18.372
5¾	4.801	6.001	7.202	8.402	9.602	12.002	14.404	16.804	19.204
6	5.010	6.262	7.515	8.767	10.020	12.524	15.030	17.535	20.042

WEIGHT OF ONE SQUARE FOOT OF SHEET IRON, ETC.

Names.	Thickness by the Birmingham (Eng.) Wire Gauge.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Iron..	12.50	12.00	11.00	10.00	8.74	8.12	7.50	6.86	6.24	5.62	5.00	4.38	3.75	3.12	2.82
Cop...	14.50	13.90	12.75	11.00	10.10	9.40	8.70	7.90	7.20	6.50	5.80	5.08	4.34	3.60	3.27
Brass	13.75	13.20	12.10	11.90	9.61	8.93	8.25	7.54	6.86	6.18	5.50	4.81	4.12	3.43	3.10

Thickness by the Wire Gauge.

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Iron..	2.50	2.18	1.86	1.70	1.54	1.40	1.25	1.12	1.00	.90	.80	.72	.61	.56	.50
Cop..	2.90	2.52	2.15	1.97	1.78	1.62	1.45	1.30	1.16	1.04	.92	.83	.74	.64	.58
Brass	2.75	2.40	2.04	1.87	1.69	1.54	1.37	1.23	1.10	.99	.88	.79	.70	.61	.55

No. 1 Wire Gauge is 5-16th of an inch: No. 4 is 1-4th; No. 11 is 1-8th; No. 13 is 1-12th; No. 15 is 1-14th; No. 16 is 1-16th; No. 17 is 1-18th; No. 19 is 1-23; No. 22 is 1-32.

RUSSIA SHEET IRON

Measures 56 by 28 inches, and is rated by the weight per sheet. The numbers run from 8 to 18 Russian lbs. per sheet. 8 Russian pounds equal 7.2 English pounds; 9=8.1 lbs.; 19=9 lbs.; 11=10 lbs.; 12=11.2 lbs. &c. 100 Russian lbs. equal 90 lbs. English.

WEIGHT OF ONE SQUARE FOOT OF PLATE IRON, ETC.

Thickness in parts of an inch.	Iron.	Copper.	Brass.	Lead.	Thickness in parts of an inch.	Iron.	Copper.	Brass.	Lead.
1/16	2.5	2.9	2.7	3.7	7/16	17.5	20.3	19.0	25.9
1/8	5.0	5.8	5.5	7.4	1/2	20.0	23.2	21.8	29.6
3/16	7.5	8.7	8.2	11.1	5/8	25.0	28.9	27.1	37.0
1/4	10.0	11.6	10.9	14.8	3/4	30.0	34.7	32.5	44.4
5/16	12.5	14.5	13.6	18.5	7/8	35.0	40.4	37.9	57.8
3/8	15.0	17.4	16.3	22.2	1	40.0	46.2	43.3	69.2

WEIGHT ONE FOOT IN LENGTH OF SQUARE AND ROUND BAR IRON.

Side and diameter in inches.	Square iron in pounds.	Round Iron in pounds.	Size and diameter in inches.	Square Iron in pounds.	Round Iron in pounds.	Side and diameter in inches.	Square iron in pounds.	Round Iron in pounds.
1/4	.209	.164	1 5/8	8.820	6.928	3 3/4	46.969	36.895
5/16	.326	.256	1 3/4	10.229	8.043	3 7/8	50.153	39.390
3/8	.470	.369	1 7/8	11.743	9.224	4	53.440	41.984
7/16	.640	.503	2	13.360	10.496	4 1/8	56.833	44.637
1/2	.835	.656	2 1/8	15.083	11.846	4 1/4	60.329	47.385
9/16	1.057	.831	2 1/4	16.909	13.283	4 3/8	63.930	50.211
5/8	1.305	1.025	2 3/8	18.840	14.797	4 1/2	67.637	53.132
11/16	1.579	1.241	2 1/2	20.875	16.396	4 5/8	71.445	56.113
3/4	1.879	1.476	2 5/8	23.115	18.146	4 3/4	75.359	59.187
13/16	2.205	1.732	2 3/4	25.259	19.842	4 7/8	79.378	62.344
7/8	2.558	2.011	2 7/8	27.608	21.684	5	83.510	65.585
15/16	2.936	2.306	3	30.070	23.653	5 1/4	92.459	72.618
1	3.340	2.624	3 1/8	32.618	25.620	5 1/2	101.036	79.370
1 1/8	4.228	3.321	3 1/4	35.279	27.709	5 3/4	110.429	86.731
1 1/4	5.219	4.099	3 3/8	38.045	29.881	6	120.243	94.610
1 3/8	6.315	4.961	3 1/2	40.916	32.170			
1 1/2	7.516	5.913	5 5/8	43.890	34.472			

The weight of bar iron being 1;
" " " cast iron — .95
" " " steel, 1.03
" " " copper, 1.16

CAST IRON.—WEIGHT OF A FOOT IN LENGTH OF SQUARE AND ROUND.

SQUARE.				ROUND.			
Size.	Weight	Size.	Weight	Size.	Weight	Size.	Weight
Inches Square	Pounds	Inches Square	Pounds	Inches Diam.	Pounds	Inches Diam.	Pounds
½	.78	4⅞	74.26	½	.61	4⅞	58.32
⅝	1.22	5	78.12	⅝	.95	5	61.35
¾	1.75	5⅛	82.08	¾	1.38	5⅛	64.46
⅞	2.39	5¼	86.13	⅞	1.87	5¼	67.64
1	3.12	5⅜	90.28	1	2.45	5⅜	70.09
1⅛	3.95	5½	94.53	1⅛	3.10	5½	74.24
1¼	4.88	5⅝	98.87	1¼	3.83	5⅝	77.65
1⅜	5.90	5¾	103.32	1⅜	4.64	5¾	81.14
1½	7.03	5⅞	107.86	1½	5.52	5⅞	84.71
1⅝	8.25	6	112.50	1⅝	6.48	6	88.35
1¾	9.57	6¼	122.08	1¾	7.51	6¼	95.87
1⅞	10.98	6½	132.03	1⅞	8.62	6½	103.69
2	12.50	6¾	142.38	2	9.81	6¾	111.82
2⅛	14.11	7	153.12	2⅛	11.08	7	120.26
2¼	15.81	7¼	164.25	2¼	12.42	7¼	129.
2⅜	17.62	7½	175.78	2⅜	13 84	7½	138.05
2½	19.53	7¾	187.68	2½	15.33	7¾	147.41
2⅝	21.53	8	200.	2⅝	16.91	8	157-08
2¾	23.63	8¼	212.56	2¾	18.56	8¼	167.05
2⅞	25.83	8½	225.78	2⅞	20.28	8½	177.10
3	28.12	8¾	239.25	3	22.18	8¾	187.91
3⅛	30.51	9	253.12	3⅛	23.96	9	198.79
3¼	33.	9¼	267.38	3¼	25.92	9¼	210.
3⅜	35.59	9½	282.	3⅜	27.95	9½	221.50
3½	38.28	9¾	297.07	3½	30.16	9¾	233.31
3⅝	41.06	10	312.50	3⅝	32.25	10	245.43
3¾	43.94	10¼	328.32	3¾	34.51	10¼	257.86
4⅞	46.92	10½	344.53	3⅞	36.85	10½	270.59
4	50.	10¾	361.13	4	39.27	10¾	283.63
4⅛	53.14	11	378.12	4⅛	41.76	11	296.97
4¼	56.44	11¼	395.50	4¼	44.27	11¼	310.63
4⅜	59.81	11½	413.28	4⅜	46.97	11½	324.59
4½	63.28	11¾	431.44	4½	49.70	11¾	338.85
4⅝	66.84	12	450.	4⅝	52.50	12	353.43
4¾	70.50			4¾	55.37		

STEEL.—WEIGHT OF A FOOT IN LENGTH OF FLAT.

Size.	Thick, 1-4 in.	Thick, 3-8ths.	Thick, 1-2 in.	Thick, 5-8ths	Size.	Thick, 1-4 in.	Thick, 3 8ths	Thick, 1-2 in.	Thick, 5-8ths.
Inch.	lbs.	lbs.	lbs.	lbs.	Inch.	lbs.	lbs.	lbs.	lbs.
1	.852	1.27	1.70	2.13	2½	2.13	3.20	4.26	5.32
1⅛	.958	1.43	1.91	2.39	2¾	2.34	3.51	4.68	5.85
1¼	1.06	1.59	2.13	2.66	3	2.55	3.83	5.11	6.39
1⅜	1.17	1.75	2.34	2.92	3¼	2.77	4.15	5.53	6.92
1½	1.27	1.91	2.55	3.19	3½	2.98	4.47	5.98	7.45
1¾	1.49	2.23	2.98	3.72	3¾	3.19	4 79	6.38	7.98
2	1.70	2.55	3.40	4.26	4	3.40	5.10	6.80	8.52
2¼	1.91	2.87	3.83	4.79					

PATENT IMPROVED LEAD PIPE.

SIZES AND WEIGHT PER FOOT.

Calibre.	Weight per foot		Calibre	Weight per foot		Calibre	Weight per foot		Calibre	Weight per foot		Calibre		Weight per foot	
Inches.	lbs.	oz.	Inches.	lbs.	oz.	Inches.	lbs.	oz.	Inches.	lbs.	oz.	Inches.		lbs.	oz.
⅜		6	½	1	4	¾	1	4	1	4	0	1½		5	0
⅜		8	½	1	8	¾	2	0	1	6	0	1¾		4	0
⅜		10	½	2	0	¾	2	4	1¼	2	8	2		5	0
⅜		12	½	3	0	¾	2	8	1¼	3	0	2		6	0
⅜	1	0	⅝		13	¾	3	0	1¼	3	8	2		7	0
⅜	1	8	⅝	1	0	¾	4	0	1¼	4	0	2½	¼ in. thick	11	0
½		8	⅝	1	8	1	1	8	1¼	5	0	3		13	0
½		10	⅝	2	0	1	1	12	1½	3	0	3½		15	0
½		12	⅝	2	12	1	2	0	1½	3	8	4		18	0
½		14	¾		12	1	2	8	1½	4	0	4½		20	0
½	1	0	¾		14	1	3	0	1½	4	8	5		22	0

SHEET LEAD.—Weight of a Square Foot, 2½, 3, 3½, 4, 4½, 5, 6, 7, 8½, 9, 10 lbs., and upwards.

BRASS, COPPER, STEEL AND LEAD.

WEIGHT OF A FOOT.

	BRASS.		COPPER.		STEEL.		LEAD.	
Diam. & side of Square.	Weight of Round.	Weight of Square.	Weight of Round.	Weight of Square.	Weight of Round.	Weight of Square.	Weight of Round.	Weight of Square.
In.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
¼	.17	.22	.19	.24	.17	.21		
⅜	.39	.50	.42	.54	.38	.48		
½	.70	.90	.75	.96	.67	.85		
⅝	1.10	1.40	1.17	1.50	1.04	1.33		
¾	1.59	2.02	1.69	2.16	1.50	1.91		
⅞	2.16	2.75	2.31	2.94	2.05	2.61		
1	2.83	3.60	3.02	3.84	2.67	3.40	3.87	4.93
1⅛	3.58	4.56	3.82	4.86	3.38	4.34	4.90	6.25
1¼	4.42	5.63	4.71	6.	4.18	5.32	6.06	7.71
1⅜	5.35	6.81	5.71	7.27	5.06	6.44	7.33	9.33
1½	6.36	8.10	6.79	8.65	6.02	7.67	8.72	11.11
1⅝	7.47	9.51	7.94	10.15	7.07	9.	10.21	13.04
1¾	8.66	11.03	9.21	11.77	8.20	10.14	11.87	15.12
1⅞	9.95	12.66	10.61	13.52	9.41	11.98	13.63	17.36
2	11.32	14.41	12.08	15.38	10.71	13.63	15.51	19.75
2⅛	12.78	16.27	13.64	17.36	12.05	15.80	17.51	22.29
2¼	14.32	18.24	15.29	19.47	13.51	17.20	19.63	25.
2⅜	15.96	20.32	17.03	21.69	15.05	19.17	21.80	27.80
2½	17.68	22.53	18.87	24.03	16.68	21.21	24.24	30.86
2⅝	19.50	24.83	20.81	26.50	18.39	23.41	26.72	34.02
2¾	21.40	27.25	22.84	29.08	20.18	25.70	29.33	37.34
2⅞	23.39	29.78	24.92	31.79	22.06	28.10	32.05	40.81
3	25.47	32.43	27.18	34.61	24.23	30.60	34.90	44.44

CAST IRON.

WEIGHT OF A SUPERFICIAL FOOT FROM ¼ TO 2 INCHES THICK.

Size.	Weight	Size.	Weight	Size.	Weight	Size.	Weight	Size.	Weight
In.	Lbs.	In.	Lbs.	In.	Lbs.	In.	Lbs.	In.	Lbs.
¼	9.37	⅝	23.43	1	37.50	1⅜	51.56	1¾	65.62
⅜	14.06	¾	28.12	1⅛	42.18	1½	56.25	1⅞	70.31
½	18.75	⅞	32.81	1¼	46.87	1⅝	60.93	2	75.

CAST IRON.

Weight of a Foot in Length of Flat Cast Iron.

Width of Iron.	Thick, ¼ in.	Thick, ⅜ in.	Thick, ½ in.	Thick, ⅝ in.	Thick, ¾ in.	Thick, ⅞ in.	Thick, 1 inch.
Inches.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2	1.56	2.34	3.12	3.90	4.68	5.46	6.25
2¼	1.75	2.63	3.51	4.39	5.27	6.15	7.03
2½	1.95	2.92	3.90	4.88	5.85	6.83	7.81
2¾	2.14	3.22	4.29	5.37	6.44	7.51	8.59
3	2.34	3.51	4.68	5.85	7.03	8.20	9.37
3¼	2.53	3.80	5.07	6.34	7.61	8.88	10.15
3½	2.73	4.10	5.46	6.83	8.20	9.57	10.93
3¾	2.93	4.39	5.85	7.32	8.78	10.25	11.71
4	3.12	4.68	6.25	7.81	9.37	10.93	12.50
4¼	3.32	4.97	6.64	8.30	9.96	11.62	13.28
4½	3·51	5.27	7.03	8.78	10.54	12.30	14.06
4¾	3.71	5.56	7.42	9.27	11.13	12.98	14.84
5	3.90	5.86	7.81	9.76	11.71	13.67	15.62
5¼	4.10	6.15	8.20	10.25	12.30	14.35	16.40
5½	4.29	6.44	8.59	10.74	12.89	15.03	17.18
5¾	4.49	6.73	8.98	11.23	13.46	15.72	17.96
6	4.68	7.03	9.37	11.71	14.06	16.40	18.75

SOLID CONTENTS OF EQUAL-SIDED TIMBER.

If the log is shorter than is contained in the table, take half or quarter of some length; if longer, double some length. The length of the log is given on the top of the columns, the diameter in the left hand column. To obtain the cubical contents of masts, spars, round logs, &c., subtract one-fourth from the contents.

In. Diam.	L.ft. 9	L. 10	L. 11	L. 12	L. 13	L. 14	L. 15	L. 16	L. 17	L. 18	L. 19	L. 20
6	2 3	2 6	2 9	3 0	3 3	3 6	3 9	4 0	4 3	4 6	4 9	5 0
7	3 0	3 4	3 7	4 1	4 5	4 9	5 1	5 5	5 9	6 2	6 6	6 10
8	4 1	4 4	4 10	5 4	5 9	6 2	6 7	8 0	8 5	8 10	9 3	9 8
9	5 2	5 9	6 2	6 9	7 4	7 11	8 6	9 1	9 8	10 3	10 10	11 5
10	6 2	6 10	7 8	8 4	9 0	9 8	10 4	11 0	11 8	12 4	13 0	13 8
11	7 6	8 4	9 3	10 1	10 11	11 9	12 7	13 5	14 3	15 1	15 11	16 9
12	9 0	10 0	11 0	12 0	13 0	14 0	15 0	16 0	17 0	18 0	19 0	20 0
13	10 4	11 7	12 10	14 1	15 3	16 5	17 9	18 9	19 11	21 1	22 3	23 5
14	12 2	13 7	14 11	16 4	17 8	18 11	20 3	21 7	22 11	24 3	25 7	26 11
15	14 2	15 9	17 2	18 9	20 4	21 10	23 5	25 0	26 7	28 2	29 9	31 4
16	16 0	17 10	19 6	21 4	23 1	24 10	26 7	28 4	30 1	21 10	33 7	35 4
17	18 0	20 0	2 0	24 1	26 1	28 1	30 1	32 1	34 1	36 1	38 1	40 1
18	20 3	22 6	24 9	27 0	29 3	31 6	33 9	36 0	38 3	40 6	42 9	45 0
19	22 6	25 0	27 6	30 1	32 7	35 1	37 7	41 1	43 7	46 1	48 7	52 0
20	25 0	27 10	30 10	33 4	36 1	38 10	41 7	44 4	47 2	50 0	52 6	55 9
21	27 7	30 8	33 9	36 9	39 10	42 11	46 0	49 1	52 2	55 3	58 4	61 5
22	30 2	33 6	36 10	40 4	43 8	47 0	50 4	53 8	57 0	60 4	63 8	67 0
23	33 0	36 8	49 4	44 1	47 9	51 5	55 1	58 9	62 5	66 1	69 9	73 5
24	36 0	40 0	44 0	18 0	52 0	56 0	60 0	64 0	68 0	72 0	76 0	80 0
25	39 0	43 4	48 1	52 1	56 5	60 9	65 1	69 5	73 9	78 1	82 5	86 9
26	42 2	16 11	51 7	56 4	61 0	65 8	70 4	75 0	79 8	84 4	89 0	93 8
27	45 7	50 8	55 9	60 9	65 10	70 11	76 0	81 1	86 2	91 7	96 8	101 11
28	49 0	54 5	59 10	65 4	70 9	76 2	81 7	85 0	92 5	97 10	103 3	108 8
29	52 6	58 4	64 2	70 1	75 11	81 9	87 7	93 5	99 3	106 1	112 11	117 9
30	55 9	62 0	68 3	75 0	81 3	87 6	93 9	100 0	106 3	112 6	118 9	125 0

LOGS REDUCED TO ONE INCH BOARD MEASURE.

If the log is longer than is contained in the table, take any two lengths.

The first column on the left gives the length of the log in feet. The figures under D denote the diameters of the logs in inches. Fractional parts of inches are not given.

The diameter of timber is usually taken 20 feet from the butt. All logs short of 20 feet, take the diameter at the top, or small end.

To find the number of feet of boards which a log will produce when sawed, take the length of feet in the first column on the left hand, and the diameter at the top of the page in inches.

Suppose a log 12 feet long and 24 inches in diameter; in the left hand column is the length, and opposite 12 under 24 is 300, the number of feet of boards in a log of that length and diameter.

Lng Ft.	D. 12	D. 13	D. 14	D. 15	D. 16	D. 17	D. 18	D. 19	D. 20	D. 21	D. 22	D. 23	D. 24
10	54	66	76	93	104	170	137	154	176	194	210	237	256
11	59	72	83	102	114	131	151	169	196	213	231	261	270
12	64	78	90	111	124	143	164	184	214	232	252	285	300
13	69	84	97	120	134	154	177	199	231	251	273	308	327
14	74	90	104	129	144	166	191	214	249	270	293	332	350
15	79	96	111	138	154	177	204	229	266	289	314	355	376
16	84	102	118	146	164	189	217	244	284	308	335	379	401
17	89	108	126	155	173	200	231	259	301	327	356	402	426
18	94	114	133	164	183	212	244	274	319	346	377	426	451
19	99	121	140	173	193	223	257	289	336	365	398	449	477
20	104	127	147	182	203	236	271	304	354	384	419	473	501
21	109	133	154	191	213	247	284	319	371	403	440	497	527
22	114	139	161	200	223	259	297	334	389	422	461	520	552
23	119	145	168	209	233	270	311	349	407	441	481	542	568
24	124	151	176	218	243	282	324	364	424	460	502	563	613
25	129	157	183	227	253	293	337	379	442	479	523	591	628
26	134	163	190	236	263	305	350	394	459	498	544	615	653
27	139	169	197	245	273	316	363	409	477	517	565	639	678
28	144	175	204	254	283	328	376	424	491	536	586	663	703
29	149	181	211	263	293	339	389	439	512	555	607	687	728
30	154	187	218	272	303	351	402	454	529	574	628	711	753
31	159	193	225	281	313	362	415	469	547	593	649	735	778

Lng Ft.	D. 25	D. 26	D. 27	D. 28	D. 29	D. 30	D. 31	D. 32	D. 33	D. 34	D. 35	D. 36
10	283	309	339	359	377	407	440	456	486	496	543	573
11	311	340	374	396	415	447	484	502	535	546	598	630
12	340	371	408	432	453	489	528	548	584	596	653	688
13	369	404	442	469	491	530	572	594	633	646	708	746
14	397	435	476	505	529	571	618	640	682	696	762	803
15	426	465	511	541	567	612	662	686	731	746	817	861
16	455	496	545	578	605	653	706	732	780	796	872	919
17	483	527	579	614	643	694	751	778	829	846	927	976
18	512	558	613	650	681	735	795	824	878	896	981	1034
19	541	590	647	688	719	776	839	870	927	946	1036	1092
20	569	621	681	724	757	817	884	916	976	996	1091	1148
21	598	652	716	760	796	859	928	962	1025	1046	1146	1206
22	627	684	750	796	834	900	972	1008	1074	1096	1200	1264
23	665	715	784	833	872	941	1017	1054	1123	1146	1255	1318
24	684	746	818	869	910	982	1061	1100	1172	1196	1310	1376
25	713	777	853	906	948	1023	1105	1146	1221	1246	1365	1434
26	742	808	887	942	986	1064	1149	1192	1270	1296	1420	1492
27	771	839	921	979	1024	1105	1193	1238	1319	1336	1475	1550
28	800	870	955	1015	1063	1146	1237	1284	1368	1396	1530	1608
29	829	901	989	1052	1100	1187	1281	1330	1417	1446	1585	1666
30	858	932	1023	1088	1138	1228	1325	1376	1466	1496	1640	1724
31	887	963	1057	1125	1176	1269	1369	1422	1515	1546	1695	1782

RELATIVE STRENGTH OF CAST AND MALLEABLE IRON.

It has been found, in the course of the experiments made by Mr. Hodgkinson and Mr. Fairbairn, that the average strain that cast iron will bear in the way of tension, before breaking, is about seven tons and a half per square inch ; the weakest, in the course of 16 trials on various descriptions, bearing 6 tons, and the strongest $9\frac{3}{4}$ tons. The experiments of Telford and Brown show that malleable iron will bear, on an average, 27 tons ; the weakest bearing 24, and the strongest 29 tons. On approaching the breaking point, cast iron may snap in an instant, without any previous symptom, while wrought iron begins to stretch, with half its breaking weight, and so continues to stretch till it breaks. The experiments of Hodgkinson and Fairbairn show also that cast iron is capable of sustaining compression to the extent of nearly 50 tons on the square inch ; the weakest bearing $36\frac{1}{2}$ tons, and the strongest 60 tons. In this respect, malleable iron is much inferior to cast iron. With 12 tons on the square inch it yields, contracts in length, and expands laterally ; though it will bear 27 tons, or more, without actual fracture.

WEIGHT.

To find the Weight of any Casting.

Width in $\frac{1}{4}$ ins. × Thickness in $\frac{1}{8}$ ins., or vice versa, $\div$ 10 × Length, ft. = Weight, lbs. cast iron.

For instance : to find the weight of a casting $3\frac{1}{4}$ ins. × $1\frac{1}{8}$ ins. × 2 ft. 6 ins. long.

$$13 \times 9 \div 10 = 11{\cdot}7 \times 2{\cdot}5 = 29{\cdot}25 \text{ lbs.}$$

This rule is very useful, and can easily be remembered in the following form.

Width in $\frac{1}{4}$ ins. × Thickness in $\frac{1}{8}$ ins. or vice versa, cut off 1 figure for decimal, the result is lbs. per foot of length.

For wrought iron add $\frac{1}{20}$th to the result; for lead add $\frac{1}{2}$; for brass add $\frac{1}{7}$th ; for copper add $\frac{1}{5}$th.

To find the Weight from the Areas.

Area, sq. ins. × Length, ft. × $3\frac{1}{7}$ = Weight, lbs. cast iron.

Multiplier for Cast iron	3·156 or $3\frac{1}{7}$.
" Wrought iron	3·312 or $3\frac{1}{3}$.
" Lead	4·854.
" Brass	3·644.
" Copper	3·87.

Or, Area, sq. ins. × 10 = lbs. per yard for wrought iron.

To find the Weight in cwts.

Area, sq. ins. × Length, ft. ÷ 31·9 = Weight, cwts. cast iron. For wrought iron, divide by 33·6.

WHEEL GEARING.

The **Pitch Line** of a wheel, is the circle upon which the pitch is measured, and it is the circumference by which the diameter, or the velocity of the wheel, is measured.

The **Pitch**, is the arc of the circle of the pitch line, and is determined by the number of the teeth in the wheel.

The **True Pitch** (*Chordial*), or that by which the dimensions of the tooth of a wheel are alone determined, is a straight line drawn from the centres of two contiguous teeth upon the pitch line.

The **Line of Centres**, is the line between the centres of two wheels.

The **Radius** of a wheel, is the semi-diameter running to the periphery of a tooth. The *Pitch Radius*, is the semi-diameter running to the pitch line.

The **Length of a Tooth**, is the distance from its base to its extremity.

The **Breadth of a Tooth**, is the length of the face of wheel.

A **Cog Wheel**, is the general term for a wheel having a number of cogs or teeth set upon or radiating from its circumference.

A **Mortise Wheel**, is a wheel constructed for the reception of teeth or cogs, which are fitted into recesses or sockets upon the face of the wheel.

Plate Wheels, are wheels without arms.

A **Rack**, is a series of teeth set in a plane.

A **Sector**, is a wheel which reciprocates without forming a full revolution.

A **Spur Wheel**, is a wheel having its teeth perpendicular to its axis.

A **Bevel Wheel**, is a wheel having its teeth at an angle with its axis.

A **Crown Wheel**, is a wheel having its teeth at a right angle with its axis.

A **Mitre Wheel**, is a wheel having its teeth at an angle of 45° with its axis.

A **Face Wheel**, is a wheel having its teeth set upon one of its sides.

An **Annular** or *Internal Wheel*, is a wheel having its teeth convergent to its centre.

Spur Gear. — Wheels which act upon each other in the same plane.

Bevel Gear. — Wheels which act upon each other at an angle.

When the tooth of a wheel is made of a material different from that of the wheel, it is termed a **Cog**; in a pinion it is termed a **Leaf**, and in a trundle a **Stave**.

A wheel which impels another is termed the **Spur, Driver**, or **Leader**; the one impelled is the **Pinion, Driven**, or **Follower.**

A series of wheels in connection with each other is termed a **Train.**

When two wheels act upon one another, the greater is termed the **Wheel** and the lesser the **Pinion.**

A **Trundle, Lantern**, or **Wallower** is when the teeth of a pinion are constructed of round brass or solid cylinders set into two discs.

A **Trundle** with less than eight staves cannot be operated uniformly by a wheel with any number of teeth.

The material of which cogs are made is about one-fourth the strength of cast iron. The product of their bd^2 should be four times that of iron teeth.

Buchanan: Rules that to increase or diminish velocity in a given proportion, and with the least quantity of wheel-work, the number of teeth in each pinion should be to the number of teeth in its wheel as 1 : 3·59. Even to save space and expense, the ratio should never exceed 1 : 6.

The least number of teeth that it is practicable to give to a wheel is regulated by the necessity of having at least one pair always in action, in order to provide for the contingency of a tooth breaking.

The teeth of wheels should be as small and numerous as is consistent with strength.

When a **Pinion is driven by a wheel**, the number of teeth in the pinion should not be less than eight.

When a **Wheel is driven by a pinion**, the number of teeth in the pinion should not be less than ten.

The **Number of teeth** in a wheel should always be prime to the number of the pinion; that is, the number of teeth in the wheel should not be divisible by the number of teeth in the pinion without a remainder. This is in order to prevent the same teeth coming together so often as to cause an irregular wear of their faces. An odd tooth introduced into a wheel is termed a *hunting tooth* or *cog*.

To Compute the Pitch of a Wheel.

Rule. — Divide circumference at the pitch-line by the number of teeth.

Example. — A wheel 40 ins. in diameter requires 75 teeth; what is its pitch?

$$\frac{3{\cdot}1416 \times 40}{75} = 1{\cdot}6755 \textit{ ins.}$$

To Compute the True or Chordial Pitch.

Rule. — Divide 180° by the number of teeth, ascertain the sine of the quotient and multiply it by the diameter of the wheel.

Example. — The number of teeth is 75, and the diameter 40 inches; what is the true pitch?

$\frac{180}{75} = 2° 24'$ and *sin.* of $2° 24' = \cdot 04188$, which $\times 40 = 1\cdot 6752$ *ins.*

To Compute the Diameter of a Wheel.

Rule. — Multiply the number of teeth by the pitch, and divide the product by 3·1416.

Example. — The number of teeth in a wheel is 75, and the pitch 1·675 ins.; what is the diameter of it?

$$\frac{75 \times 1\cdot 6755}{3\cdot 1416} = 10 \textit{ ins.}$$

To Compute the Number of Teeth in a Wheel.

Rule. — Divide the circumference by the pitch.

To Compute the Diameter when the True Pitch is given.

Rule. — Multiply the number of teeth in the wheel by the true pitch, and again by ·3184.

Example. — Take the elements of the preceding case.

$$75 \times 1\cdot 6752 \times \cdot 3184 = 40 \textit{ ins.}$$

To Compute the Number of Teeth in a Pinion or Follower to have a given Velocity.

Rule. — Multiply the velocity of the driver by its number of teeth, and divide the product by the velocity of the driven.

Example. — The velocity of a driver is 16 revolutions, the number of its teeth 54, and the velocity of the pinion is 48; what is the number of its teeth?

$$\frac{16 \times 54}{48} = 18 \textit{ teeth.}$$

2. A wheel having 75 teeth is making 16 revolutions per minute; what is the number of teeth required in the pinion to make 24 revolutions in the same time?

$$\frac{16 \times 75}{24} = 50 \textit{ teeth.}$$

To Compute the Proportional Radius of a Wheel or Pinion.

Rule.—Multiply the length of the line of centres by the number of teeth in the wheel for the wheel, and in the pinion for the pinion, and divide by the number of teeth in both the wheel and pinion.

To Compute the Diameter of a Pinion, when the Diameter of the Wheel and Number of Teeth in the Wheel and Pinion are given.

Rule.—Multiply the diameter of the wheel by the number of teeth in the pinion, and divide the product by the number of teeth in the wheel.

Example.—The diameter of a wheel is 25 inches, the number of its teeth 210, and the number of teeth in the pinion 30; what is the diameter of the pinion?

$$\frac{25 \times 30}{210} = 3{\cdot}57 \textit{ inches.}$$

To Compute the Number of Teeth required in a Train of Wheels to produce a given Velocity.

Rule.—Multiply the number of teeth in the driver by its number of revolutions, and divide the product by the number of revolutions of each pinion, for each driver and pinion.

Example.—If a driver in a train of three wheels has 90 teeth, and makes 2 revolutions, and the velocities required are 2, 10, and 18, what are the number of teeth in each of the other two?

$$10 : 90 :: 2 : 18 = \textit{teeth in 2d wheel.}$$
$$18 : 90 :: 2 : 10 = \textit{teeth in 3d wheel.}$$

To Compute the Circumference of a Wheel.

Rule.—Multiply the number of teeth by their pitch.

To Compute the Revolutions of a Wheel or Pinion.

Rule.—Multiply the diameter or circumference of the wheel or the number of its teeth, as the case may be, by the number of its revolutions, and divide the product by the diameter, circumference, or number of teeth in the pinion.

Example.—A pinion 10 inches in diameter is driven by a wheel 2 feet in diameter, making 46 revolutions per minute; what is the number of revolutions of the pinion?

$$\frac{2 \times 12 \times 46}{10} = 110{\cdot}4 \textit{ revolutions.}$$

To Compute the Velocity of a Pinion.

Rule.—Divide the diameter, circumference, or number of teeth in the driver, as the case may be, by the diameter, etc., of the pinion.

When there are a Series or Train of Wheels and Pinions.

Rule. — Divide the continued product of the diameter, circumference, or number of teeth in the wheels by the continued product of the diameter, etc., of the pinions.

Example 1.—If a wheel of 32 teeth drive a pinion of 10, upon the axis of which there is one of 30 teeth, driving a pinion of 8, what are the revolutions of the last?

$$\frac{32}{10} \times \frac{30}{8} = \frac{960}{80} = 12 \textit{ revolutions.}$$

Example 2.—The diameters of a train of wheels are 6, 9, 9, 10, and 12 inches; of the pinions, 6, 6, 6, 6, and 6 inches; and the number of revolutions of the driving shaft or prime mover is 10; what are the revolutions of the last pinion?

$$\frac{6 \times 9 \times 9 \times 10 \times 12 \times 10}{6 \times 6 \times 6 \times 6 \times 6} = \frac{583200}{7776} = 75 \textit{ revolutions.}$$

To Compute the Proportion that the Velocities of the Wheels in a Train should bear to one another.

Rule.—Subtract the less velocity from the greater, and divide the remainder by one less than the number of wheels in the train; the quotient is the number, rising in arithmetical progression from the less to the greater velocity.

Example.—What should be the velocities of 3 wheels to produce 18 revolutions, the driver making 3?

$$\frac{18 - 3 = 15}{3 - 1 = 2} = \frac{15}{2} = 7{\cdot}5 = \textit{number to be added to velocity of the driver}$$

$= 7{\cdot}5 + 3 = 10{\cdot}5$, and $10{\cdot}5 + 7{\cdot}5 = 18$ *revolutions.* Hence 3, 10·5, and 18 *are the velocities of the three wheels.*

General Illustrations.

1. A wheel 96 inches in diameter, having 42 revolutions per minute, is to drive a shaft 75 revolutions per minute; what should be the diameter of the pinion?

$$\frac{96 \times 42}{75} = 53{\cdot}76 \textit{ inches.}$$

2. If a pinion is to make 20 revolutions per minute, required the diameter of another to make 58 revolutions in the same time.

$58 \div 20 = 2{\cdot}9 =$ *the ratio of their diameters.* Hence, if one to make 20 revolutions is given a diameter of 30 inches, the other will be $30 \div 2{\cdot}9 = 10{\cdot}345$ *inches.*

3. Required the diameter of a pinion to make 12½ revolutions in the same time as one of 32 inches diameter making 26.

$$\frac{32 \times 26}{12{\cdot}5} = 66{\cdot}56 \textit{ inches.}$$

4. A shaft, having 22 revolutions per minute, is to drive another shaft at the rate of 15, the distance between the two shafts upon the line of centres is 45 inches; what should be the diameter of the wheels?

Then, 1st. $22 + 15 : 22 :: 45 : 26{\cdot}75 =$ *inches in the radius of the pinion.*
2d. $22 + 15 : 15 :: 45 : 18{\cdot}24 =$ *inches in the radius of the spur.*

5. A driving shaft, having 16 revolutions per minute, is to drive a shaft 81 revolutions per minute, the motion to be communicated by two geared wheels and two pulleys, with an intermediate shaft; the driving wheel is to contain 54 teeth, and the driving pulley upon the driven shaft is to be 25 inches in diameter; required the number of teeth in the driven wheel, and the diameter of the driven pulley.

Let the driven wheel have a velocity of $\sqrt{16 \times 81} = 36$, a mean proportional between the extreme velocities 16 and 81.

Then, 1st. $36 : 16 :: 54 : 24 =$ *teeth in the driven wheel.*

2d. $81 : 36 :: 25 : 11{\cdot}11 =$ *inches diameter of the driven pulley.*

6. If, as in the preceding case, the whole number of revolutions of the driving shaft, the number of teeth in its wheel, and the diameters of the pulleys are given, what are the revolutions of the shafts?

Then, 1st. $18 : 16 :: 54 : 48 =$ *revolutions of the intermediate shaft.*
2d. $15 : 48 :: 25 : 80 =$ *revolutions of the driven shaft.*

To Compute the Diameter of a Wheel for a given Pitch and Number of Teeth.

Rule. — Multiply the diameter in the following table for the number of teeth by the pitch, and the product will give the diameter at the pitch circle.

Example.—What is the diameter of a wheel to contain 48 teeth of 2·5 inches pitch?

$$15{\cdot}29 \times 2{\cdot}5 = 38{\cdot}225 \textit{ inches.}$$

To Compute the Pitch of a Wheel for a given Diameter and Number of Teeth.

Rule.—Divide the diameter of the wheel by the diameter in the table for the number of teeth, and the product will give the pitch.

Example.—What is the pitch of a wheel when the diameter of it is 50·94 inches, and the number of its teeth 80?

$$\frac{50{\cdot}94}{25{\cdot}47} = 2 \textit{ inches.}$$

PITCH OF WHEELS.

A TABLE WHEREBY TO COMPUTE THE DIAMETER OF A WHEEL FOR A GIVEN PITCH, OR THE PITCH FOR A GIVEN DIAMETER.

From 8 *to* 192 *feet.*

No. of Teeth.	Diameter.	No. of Teeth.	Diameter.	No. of Teeth.	Diameter.	No. of Teeth.	Diameter.	No of Teeth.	Diameter.
8	2 61	45	14·33	82	26·11	119	37·88	156	49·66
9	2·93	46	14·65	83	26·43	120	38·2	157	49·98
10	3·24	47	14·97	84	26·74	121	38·52	158	50·3
11	3·55	48	15·29	85	27·06	122	38 84	159	50·61
12	3·86	49	15·61	86	27·38	123	39·16	160	50·93
13	4·18	50	15·93	87	27·7	124	39·47	161	51·25
14	4·49	51	16·24	88	28·02	125	39·79	162	51·57
15	4·81	52	16·56	89	28·33	126	40·11	163	51·89
16	5·12	53	16·88	90	28·65	127	40·43	164	52·21
17	5·44	54	17·2	91	28·97	128	40·75	165	52·52
18	5·76	55	17·52	92	29·29	129	41·07	166	52 84
19	6·07	56	17·8	93	29·61	130	41·38	167	53·16
20	6·39	57	18·15	94	29·93	131	41·7	168	53·48
21	6·71	58	18·47	95	30·24	132	42·02	169	53·8
22	7·03	59	18·79	96	30·56	133	42·34	170	54·12
23	7·34	60	19·11	97	30·88	134	42·66	171	54·43
24	7·66	61	19·42	98	31·2	135	42·98	172	54·75
25	7·98	62	19·74	99	31·52	136	43·29	173	55·07
26	8·3	63	20·06	100	31·84	137	43·61	174	55·39
27	8·61	64	20·38	101	32·15	138	43·93	175	55·71
28	8·93	65	20·7	102	32 47	139	44·25	176	56·02
29	9·25	66	21·02	103	32·79	140	44·57	177	56·34
30	9·57	67	21·33	104	33·11	141	44·88	178	56·66
31	9·88	68	21·65	105	33·43	142	45 2	179	56·98
32	10·2	69	21·97	106	33·74	143	45·52	180	57·23
33	10·52	70	22·29	107	34·06	144	45·84	181	57·62
34	10·84	71	22·61	108	34·38	145	46·16	182	57·93
35	11·16	72	22·92	109	34·7	146	46·48	183	58·25
36	11·47	73	23·24	110	35·02	147	46·79	184	58 57
37	11·79	74	23·56	111	35·34	148	47·11	185	58·89
38	12·11	75	23·88	112	35·65	149	47·43	186	59·21
39	12 43	76	24·2	113	35·97	150	47·75	187	59·53
40	12·74	77	24·52	114	36·29	151	48·07	188	59·84
41	13·06	78	24·83	115	36·61	152	48·39	189	60·16
42	13·38	79	25·15	116	36·93	153	48·7	190	60·48
43	13·7	80	25.47	117	37·25	154	49·02	191	60·81
44	14·02	81	25·79	118	37·56	155	49·34	192	61·13

NOTE. — The pitch in this table is the true pitch, as before described.

To Compute the Number of Teeth of a Wheel for a given Diameter and Pitch.

Rule. — Divide the diameter by the pitch, and opposite to the quotient in the table is given the number of teeth. (See p. 154.)

Change Wheels in Screw-cutting Lathes.

$\frac{T\,S}{t\,t'}\,I = N$; $\frac{t\,t'}{I\,T} = S$. T *representing number of teeth in traverse screw;* S *number in stud-wheel gearing in mandril; t number in wheel upon mandril, and t′ number in gearing upon stud pinion, gearing in* T; I *number of threads per inch upon traverse screw;* N *number to be cut.*

To determine the Proportion of Wheels for Screw-cutting by a Lathe.

In a lathe properly adapted, screws to any degree of pitch, or number of threads in a given length, may be cut by means of a leading screw of any given pitch, accompanied with change wheels and pinions; coarse pitches being effected generally by means of one wheel and one pinion with a *carrier*, or *intermediate wheel*, which cause no variation or change of motion to take place. Hence the following

Rule.— Divide the number of threads in a given length of the screw which is to be cut by the number of threads in the same length of the leading screw attached to the lathe; and the quotient is the ratio that the wheel on the end of the screw must bear to that on the end of the lathe spindle.

Example.— Let it be required to cut a screw with 5 threads in an inch, the leading screw being of $\frac{1}{2}$ inch pitch, or containing 2 threads in an inch; what must be the ratio of wheels applied?

$5 \div 2 = 2{\cdot}5$, the ratio they must bear to each other.

Then suppose a pinion of 40 teeth be fixed upon for the spindle.

$40 \times 2{\cdot}5 = 100$ teeth for the wheel on the end of the screw.

But screws of a greater degree of fineness than about 8 threads in an inch are more conveniently cut by an additional wheel and pinion, because of the proper degree of velocity being more effectively attained; and these, on account of revolving upon a stud, are commonly designated the *stud wheels*, or *stud-wheel and pinion;* but the mode of calculation and ratio of screw are the same as in the preceding rule. Hence, all that is further necessary is to fix upon any three wheels at pleasure, as those for the spindle and stud-wheels; then multiply the number of teeth in the spindle-wheel by the ratio of the screw, and by the number of teeth in that wheel or pinion which is in contact with the wheel on the end of the screw; divide the product by the stud-wheel in contact with the spindle-wheel; and the quotient is the number of teeth required in the wheel on the end of the leading screw.

Example.— Suppose a screw is required to be cut containing 25 threads in an inch, and the leading screw, as before, having two threads in an inch, and that a wheel of 60 teeth is fixed upon for the end of the spindle, 20 for the pinion in contact with the screw-wheel, and 100 for that in contact with the wheel on the end of the spindle; required the number of teeth in the wheel for the end of the leading screw.

$$25 \div 2 = 12{\cdot}5, \text{ and } \frac{60 \times 12{\cdot}5 \times 20}{100} = 150 \text{ teeth.}$$

Or suppose the spindle and screw-wheels to be those fixed upon, also any one of the stud-wheels, to find the number of teeth in the other.

$$\frac{60 \times 12{\cdot}5}{150 \times 100} = 20 \text{ teeth, or } \frac{60 \times 12{\cdot}5 \times 20}{150} = 100 \text{ teeth.}$$

TABLE OF CHANGE WHEELS FOR SCREW-CUTTING.

The leading Screw being ½ inch pitch, or containing 2 threads in an inch.

Number of threads in inch of screw.	Number of teeth in		Number of threads in inch of screw.	Number of teeth in				Number of threads in inch of screw.	Number of teeth in			
	Lathe spindle-wheel.	Leading screw-wheel.		Lathe spindle-wheel.	Wheel in contact with spindle-wheel.	Pinion in contact with screw-wheel.	Leading screw-wheel.		Lathe spindle-wheel.	Wheel in contact with spindle-wheel.	Pinion in contact with screw-wheel.	Leading screw-wheel.
1	80	40	8¼	40	55	20	60	19	50	95	20	100
1¼	80	50	8½	90	85	20	90	19½	80	120	20	130
1½	80	60	8¾	60	70	20	75	20	60	100	20	120
1¾	80	70	9½	90	90	20	95	20¼	40	90	20	90
2	80	90	9¾	40	60	20	65	21	80	120	20	140
2¼	80	90	10	60	75	20	80	22	60	110	20	120
2½	80	100	10½	50	70	20	75	22½	80	120	20	150
2¾	80	110	11	60	55	20	120	22¾	80	130	20	140
3	80	120	12	90	90	20	120	23¾	40	95	20	100
3¼	80	130	12¾	60	85	20	90	24	65	120	20	130
3½	80	140	13	90	90	20	130	25	60	100	20	150
3¾	40	150	13½	60	90	20	90	25½	30	85	20	90
4	40	80	13¾	80	100	20	110	26	70	130	20	140
4¼	40	85	14	90	90	20	140	27	40	90	20	120
4½	40	90	14¼	60	90	20	95	27½	40	100	20	110
4¾	40	95	15	90	90	20	150	28	75	140	20	150
5	40	100	16	60	80	20	120	28½	30	90	20	95
5½	40	110	16¼	80	100	20	130	30	70	140	20	150
6	40	120	16½	80	110	20	120	32	30	80	20	120
6½	40	130	17	45	85	20	90	33	40	110	20	120
7	40	140	17½	80	100	20	140	34	30	85	20	120
7½	40	150	18	40	60	20	120	35	60	140	20	150
8	30	210	18¾	80	100	20	150	36	30	190	20	120

Example 1. — Required the number of teeth that a wheel of 16 inches diameter will contain of a 10 pitch.

$16 \times 10 = 160$ teeth, and the circular pitch = ·314 inch.

Example 2. — What must be the diameter of a wheel for a 9 pitch of 126 teeth?

$126 \div 9 = 14$ inches diameter, circular pitch ·349 inch.

Note. — The pitch is reckoned on the diameter of the wheel instead of the circumference, and designated wheels of 8 pitch, 12 pitch, etc.

STRENGTH OF THE TEETH OF CAST IRON WHEELS AT A GIVEN VELOCITY.

Pitch of teeth in inches.	Thickness of teeth in inches.	Breadth of teeth in inches.	Strength of teeth in horse-power at			
			3 feet per second.	4 feet per second.	6 feet per second.	8 feet per second.
3·99	1·9	7·6	20·57	27·43	41·14	54·85
3·78	1·8	7·2	17·49	23·32	34·98	46·64
3·57	1·7	6·8	14·73	19·65	29·46	39·28
3·36	1·6	6·4	12·28	16·38	24·56	32·74
3·15	1·5	6·	10·12	13·50	20·24	26·98
2·94	1·4	5·6	8·22	10·97	16·44	21·92
2·73	1·3	5·2	6·58	8·78	13·16	17·54
2·52	1·2	4·8	5·18	6 91	10·36	13·81
2·31	1·1	4·4	3·99	5·32	7·98	10 64
2·1	1·0	4·	3·00	4·00	6·00	8·00
1·89	·9	3·6	2·18	2·91	4·36	5·81
1·68	·8	3·2	1·53	2·04	·06	3·08
1·47	·7	2·8	1·027	1·37	2·04	2 72
1.26	·6	2·4	·64	·86	1·38	1·84
1·05	·5	2·	·375	·50	·75	1·00

WHEELS AND GUDGEONS.

To find size of Teeth necessary to Transmit a given Horse Power. (Tredgold.)

$$\frac{\text{Horse power} \times 240}{\text{Diameter of wheel, ft.} \times \text{Revs. per min.}} = \text{Strength of tooth.}$$

$$\sqrt{\frac{\text{Strength}}{\text{Breadth, ins.}}} = \text{Pitch, ins.} \quad \frac{\text{Strength}}{(\text{Pitch, ins.})^2} = \text{Breadth, ins.}$$

The above rule will be found very suitable for a speed of circumference of about 240 feet per minute. For speeds above, add to 240 half the difference; for speeds below, deduct half the difference between 240 and the actual speed, the result being a suitable multiplier.

For instance: at 300 feet per minute, 60 being the difference, $240 + 30 = 270$ multiplier.

At 160 feet per minute, 80 being the difference, $240 - 40 = 200$ multiplier.

The reason being that, with higher speeds, the friction, wear, and liability to shocks is increased, at lower speeds decreased, and the teeth may advantageously be proportioned accordingly.

To find the Horse Power that any Wheel will Transmit.

$$\frac{(\text{Pitch, ins.})^2 \times \text{Breadth, ins.} \times \text{Diameter, ft.} \times \text{Revs. per minute}}{\text{Appropriate No. according to speed, as above}}$$
$$= \text{Horse Power.}$$

To find the Multiplying Number for any Wheel.

$$\frac{(\text{Pitch, ins.})^2 \times \text{Breadth, ins.} \times \text{Diameter, ft.} \times \text{Revs. per minute}}{\text{Horse Power}}$$
$$= \text{Multiplying No. as above.}$$

To find the Size of Teeth to carry a given Load in Pounds.

Load, lbs. $\div$ 1120 = Breaking strength of teeth.

Load, lbs. $\div$ 280 = Strength for very low speeds, and for steady work; being 4 times the breaking strength.

Load, lbs. $\div$ 140 = Strength for ordinary purposes of machinery; being 8 times the breaking strength.

Load, lbs. $\div$ 100 = Strength for high speeds and irregular work; or when the teeth are exposed to shocks.

As before,

$$\frac{\text{Strength}}{(\text{Pitch, ins.})^2} = \text{Breadth, ins.} \quad \sqrt{\frac{\text{Strength}}{\text{Breadth, ins.}}} = \text{Pitch, ins.}$$

WATER.

To find the Quantity of Water that will be Discharged through an Orifice or Pipe in the Side or Bottom of a Vessel.

$$\text{Area of orifice, sq. in.} \times \left\{\begin{array}{c}\text{No. corresponding to height of surface}\\ \text{above orifice, as per table}\end{array}\right. = \text{Cubic feet discharged per minute.}$$

Height of Surface above Orifice.	Multiplier.	Height of Surface above Orifice.	Multiplier.	Height of Surface above Orifice.	Multiplier.
Feet.		Feet.		Feet.	
1	2·25	18	9·5	40	14·2
2	3·2	20	10·	45	15·1
4	4·5	22	10·5	50	16·
6	5·44	24	11·	60	17·4
8	6·4	26	11·5	70	18·8
10	7·1	28	12·	80	20·1
12	7·8	30	12·3	90	21·3
14	8·4	32	12·7	100	22·5
16	9·	35	13·3		

To find the Size of Hole necessary to Discharge a given Quantity of Water under a given Head.

$$\frac{\text{Cubic feet water discharged}}{\text{No. corresponding to height, as per table}} = \text{Area of orifice, sq. in.}$$

To find the Height necessary to Discharge a given Quantity through a given Orifice.

$$\frac{\text{Cubic feet water discharged}}{\text{Area orifice, sq. inches}} = \text{No. corresp. to height, as per table.}$$

The Velocity of Water issuing from an Orifice in the Side or Bottom of a Vessel being ascertained to be as follows:

$$\sqrt{\text{Height ft. surface above orifice}} \times 5{\cdot}4 = \left\{\begin{array}{c}\text{Velocity of water, ft.}\\ \text{per second.}\end{array}\right.$$

$$\sqrt{\text{Height ft.}} \times \text{Area orifice, ft.} \times 324 = \left\{\begin{array}{c}\text{Cubic feet discharged}\\ \text{per minute.}\end{array}\right.$$

$$\sqrt{\text{Height ft.}} \times \text{Area orifice, ins.} \times 2.2 = \text{Do.} \quad \text{Do.}$$

It may be observed that the above rules represent the actual quantities that will be delivered through a hole cut in the plate: if a short pipe be attached, the quantity will be increased, the greatest delivery with a straight pipe being attained with a length equal to 4 diameters, and being $\frac{1}{3}$ more than the delivery through the plain hole; the quantity gradually decreasing as the length of pipe is increased, till, with a length equal to 60 diameters, the discharge again equals the discharge through the plain orifice. If a taper pipe be attached, the delivery will be still greater, being $1\frac{1}{2}$ times the delivery through the plain orifice; and it is probable that if a pipe with curved decreasing taper were to be tried, the delivery through it would be equal to the theoretical discharge, which is about 1.65 the actual discharge through a plain hole.

To find the Quantity of Water that will run through any Orifice, the top of which is level with the Surface of Water as over a Sluice or Dam.

$$\sqrt{\left.\begin{matrix}\text{Height, ft. from water surface to}\\ \text{bottom of orifice or top of dam}\end{matrix}\right\}} \times \left.\begin{matrix}\text{Area of water}\\ \text{passage,sq.ft.}\end{matrix}\right\} \times 256$$

$=$ Cubic feet discharged per minute.

Or,

Two-thirds area of water passage, sq. ins. $\times$ No. corresponding to height as per table $=$ Cubic feet discharged per minute.

To find the time in which a Vessel will empty itself through a given Orifice.

$$\frac{\sqrt{\text{Height, feet surface above orifice}} \times \text{Area water surface, sq. ins.}}{\text{Area orifice, square inch} \times 3{\cdot}7}$$

$=$ Time required, seconds.

The above rules are founded on Bank's experiments.

GAUGING OF CASKS.

In taking the dimensions of a Cask, it must be carefully observed: 1st, That the bung-hole be in the middle of the cask; 2d, That the bung-stave, and the stave opposite to the bung-hole, are both regular and even within; 3d, That the heads of the Cask are equal, and truly circular; if so, the distance between the inside of the chime to the outside of the opposite stave will be the head diameter within the cask, very near.

Rule. — Take, in inches, the *inside* diameters of a cask at the head and the bung, and also the length; subtract the head-diameter from the bung-diameter, and note the difference.

If the measure of the Cask is taken outside, with callipers, from head to head, then a deduction must be made of from 1 to 2 inches for the thickness of the heads, according to the size of the Cask.

1. *If the staves of the Cask, between the bung and the head, are considerably curved,* (the shape of a pipe,) multiply the difference between the bung and head by ·7.

2. *If the staves be of a medium curve,* (the shape of a molasses hogshead,) multiply the difference by ·65.

3. *If the staves curve very little,* (less than a molasses hogshead,) multiply the difference by ·6.

4. *If the staves are nearly straight,* (almost a cylinder,) multiply the difference by ·55.

5. Add the product, in each case, to the head-diameter; the sum will be a mean diameter, and thus the Cask is reduced to a cylinder.

6. Multiply the *mean* diameter by itself, and then by the length, and multiply, if for Wine gallons, by ·0034. The difference of dividing by 294, (the usual method,) and multiplying by ·0034, (the most expeditious method,) is less than 500ths of a gallon in 100 gallons.

Example. — Supposing the head-diameter of a Cask to be 24 inches, the bung-diameter 32 inches, and the length of Cask 40 inches, what is the contents in Wine gallons?

First variety.

Bung-Diameter,	32	Brought up,	876·16
Head-Diameter,	24	Length,	40
Difference,	8		35046·40
Multiplier,	·7		·0034
	5·6		14018560
Head-Diam.,	24		10513920
	29·6		119·157760
Multiply by	29·6		
[Carry up] Square,	876·16	*Ans.*	119 galls. 1 pint.

To obtain the contents of a similar Cask in Ale gallons, multiply 35046·40 by ·002785, and we get 97·6042, (or 97 gallons 5 pints.)

Gauging of Casks in Imperial (British) Gallons, and also in United States Gallons.

Having ascertained the *variety* of the Cask, and its *interior* dimensions, the following Table will facilitate the calculation of its capacity.

TABLE OF THE CAPACITIES OF CASKS, WHOSE BUNG DIAMETERS AND LENGTHS ARE 1 OR UNITY.

H.	1st Var.	2d Var.	3d Var.	4th Var.	H.	1st Var.	2d Var.	3d Var.	4th Var.
·50	·0021244	·0020300	·0017704	·0016523	·76	·0024337	·0024120	·0022343	·0022071
·51	·0021340	·0020433	·0017847	·0016713	·77	·0024482	·0024282	·0022560	·0022310
·52	·0021437	·0020567	·0017993	·0016905	·78	·0024628	·0024445	·0022780	·0022551
·53	·0021536	·0020702	·0018141	·0017098	·79	·0024777	·0024610	·0023002	0022794
·54	·0021637	·0020838	·0018293	·0017294	·80	·0024927	·0024776	·0023227	0023038
·55	·0021740	·0020975	·0018447	·0017491	·81	·0025079	·0024942	·0023455	·0023285
·56	0021845	·0021114	·0018604	·0017690	·82	·0025233	·0025110	·0023686	0023533
·57	·0021951	·0021253	·0018764	·0017891	·83	·0025388	·0025279	·0023920	·0023783
·58	·0022060	·0021394	·0018927	·0018094	·84	·0025546	·0025449	·0024156	·0024035
·59	·0022170	·0021536	·0019093	·0018299	·85	·0025706	·0025621	·0024396	·0024289
·60	·0022283	·0021679	·0019261	·0018506	·86	·0025867	·0025793	·0024638	·0024545
·61	·0022397	·0021823	·0019433	·0018715	·87	·0026030	·0025967	·0024883	·0024803
·62	·0022513	·0021968	·0019607	·0018925	·88	·0026196	·0026141	·0025131	·0025063
·63	·0022631	·0022114	·0019784	·0019138	·89	·0026363	·0026317	·0025381	·0025324
·64	·0022751	·0022262	·0019964	·0019352	·90	·0026532	·0026494	·0025635	·0025588
·65	·0022873	·0022410	·0020147	·0019568	·91	·0026703	·0026672	·0025891	0025853
·66	·0022997	·0022560	·0020332	·0019786	·92	·0026875	·0026851	·0026150	0026120
·67	·0023122	·0022711	·0020521	·0020006	·93	·0027050	·0027032	·0026412	0026389
·68	·0023250	·0022863	·0020712	·0020228	·94	·0027227	·0027213	·0026677	·0026660
·69	·0023379	·0023016	·0020906	·0020452	·95	·0027405	·0027396	·0026945	·0026933
·70	·0023510	·0023170	·0021103	·0020678	·96	·0027585	·0027579	·0027215	·0027208
·71	·0023643	·0023326	·0021302	·0020905	·97	·0027768	·0027764	·0027489	·0027484
·72	·0023778	·0023482	·0021505	·0021135	·98	·0027952	·0027950	·0027765	·0027763
·73	·0023915	·0023640	·0021710	·0021366	·99	·0028138	·0028137	·0028044	·0028043
·74	·0024054	·0023799	·0021918	·0021599	1·00	·0028326	·0028326	·0028326	·0028326
·75	·0024195	·0023959	·0022129	·0021834					

Divide the head by the bung diameter, and opposite the quotient in the column H, and under its proper variety, is the tabular number for unity. Multiply the tabular number by the square of the bung diameter of the given cask, and by its length, the product equals its capacity in Imperial gallons.

Required the number of gallons in a Cask, (1*st variety*,) 24 inches head-diameter, 32 bung-diameter, and 40 inches in length?

32) 24·0 (·75 see Table for tabular No.
·0024195 tabular No. for unity.
32 × 32 is 1024 square of bung diam.

96780
48390
24195

2·4775680
40 Inches long.

99·1027200 Imperial gallons.
1·2

1982054400
991027200

118·92326400 United States gallons.

NOTE. — Multiplying Imperial gallons by one and two-tenths (1·2) will convert them into U. S. gallons; and U. S. gallons multiplied by ·833 equal Imperial gallons.

To Ullage, or find the Contents in Gallons of a Cask partly filled.

To find the contents of the occupied part of a lying cask in gallons.

RULE.— Divide the depth of the liquid, or wet inches, by the bung-diameter, and if the quotient is under ·5, deduct from the quotient *one-fourth* of what it is less than ·5, and multiply the remainder by the whole capacity of the cask; this product will be the number of gallons in the cask. But if the quotient exceeds ·5, add *one-fourth* of that excess to the quotient, and multiply the sum by the whole capacity of the cask; this product will be the number of gallons.

Example 1. — Suppose the bung-diameter of a cask, on its bilge, is 32 inches, and the whole contents of the cask 118·80 U. S. standard gallons; required the ullage of 15 wet inches.

32) 15.00 (·46875 ·5 — ·46875 = ·03125 ÷ 4 = ·0078125 ·46875 — ·0078125 = ·4609375 × 118·80 = 54·759375 U. S. gallons.

Example 2.— Required the ullage of 17 wet inches in a cask of the above capacity.

32)17·00(·53125 — ·5 = ·03125 ÷ 4 = ·0078125 + ·53125 = ·5390625 × 118 80 = 64·040625 U. S. gallons.

PROOF.— 64·040625 + 54·759375 = 118·80 *gallons*.

To find the ullage of a filled part of a standing Cask, in gallons.

RULE.— Divide the depth of the liquid, or wet inches, by the length of the cask; then, if the quotient is less than ·5, deduct from the quotient *one-tenth* of what it is less than ·5, and multiply the remainder by the whole capacity of the cask; this product will be the number of gallons. But if the quotient exceeds ·5, add *one-tenth* of that excess to the quotient, and multiply the sum by the whole capacity of the cask; this product will be the ullage, or contents in U. S. standard gallons.

Example.— Suppose a cask, 40 inches in length, and the capacity 118·80 gallons, as above: required the ullage of 21 wet inches.

40) 21·000 (·525 — .5 = ·025 ÷ 10 = ·0025 + ·525 = ·5275 × 118·80 = 62·667 U. S. gallons.

NOTE.—Formerly the British Wine and Ale gallon measures were similar to those now used in the United States and British Colonies.

The following Tables exhibit the comparative value between the United States and the present British measures.

U. S. measure for wine, spirits, etc.	British (Im.) measure. galls.	qts.	pts.	gills.	U. S. measure for ale and beer.	British (Im.) measure. galls.	qts.	pts.	gills.
42 galls. = 1 tierce, =	34	3	1	3	9 galls. = 1 firkin, =	9	0	1	1
63 " = 1 hogsh. =	52	1	1	3	36 " = 1 barrel, =	36	2	0	3
126 " = 1 pipe, =	104	3	1	3	54 " = 1 hogsh. =	54	3	0	1
252 " = 1 tun, =	209	3	1	2	108 " = 1 butt, =	109	3	1	3

To convert Imperial gallons into United States Wine gallons, multiply the imperial by 1·2. To convert U. S. gallons into Imperial, multiply the U. States Wine gallons by ·833.

51 U. S. Ale gallons equal 60 Imperial gallons, therefore to convert one into other add or deduct $\frac{1}{60}$th.

ALLOYS AND COMPOSITIONS.

Alloy is the proportion of a baser metal mixed with a finer or purer, as when copper is mixed with gold, &c.

Amalgam is a compound of mercury and a metal — a soft alloy.

All compositions of copper contract in the admixture, and all amalgams expand.

In the manufacture of alloys and compositions, the more infusible metals should be melted first.

In compositions of brass, as the proportion of zinc is increased, so is the malleability decreased.

The tenacity of brass is impaired by the addition of lead or tin.

Steel alloyed with $\frac{5}{100}$th part of platinum, or silver, is rendered harder, more malleable, and better adapted for cutting instruments.

Any alloy which is slowly heated and gradually cooled (annealed, that is), is softer than when the compound is suddenly chilled; hence the hardness of chill-cast iron.

In moulding, no casting of any kind should be removed until it is cooled down to within a few degrees of the atmosphere; and in open sand castings, a thick covering of sand should be applied to retain the heat.

Neglect of this caution is certain to weaken the piece, and frequently is the cause of accidents.

ALLOYS AND COMPOSITIONS.

	Copper.	Zinc.	Tin.	Nickel.	Lead.	Antimony	Bismuth.	Silver	Cobalt of Iron.	Iron.	Arsenic.
Argentan	55.	24.	......	21.	......	......	......	......	......	......	......
Argentiferous	50.	2.5	2.5	40.	2.5	......	......	......	......	2.5	...z
Babbitt's metal*	3.7	......	89.	......	......	7.3	......	......	......	......	......
Brass, common	84.3	5.2	10.5	......	......	......	......	......	......	......	......
“ “	75.	25.	......	......	......	......	......	......	......	......	......
“ “ hard	79.3	6.4	14.3	......	......	......	......	......	......	......	......
“ Mathematical instruments.	92.2	......	7.8	......	......	......	......	......	......	......	......
“ pinchbeck	80.	20.	......	......	......	......	......	......	......	......	......
“ red tombac	88.8	11.2	......	......	......	......	......	......	......	......	......
“ rolled	74.3	22.3	3.4	......	......	......	......	......	......	......	......
“ tutenag	50.	31.	......	19.	......	......	......	......	......	......	......
“ very tenacious	88.9	2.8	8.3	......	......	......	......	......	......	......	......
“ wheels, valves	90.	......	10.	......	......	......	......	......	......	......	......
“ white	10.	80.	10.	......	......	......	......	......	......	......	......
“ wire	67.	33.	......	......	......	......	......	......	......	......	......
“ yellow, fine	66.	34.	......	......	......	......	......	......	......	......	......
Britannia metal	......	......	25.	......	......	25.	......	......	......	......	......
When fused, add	......	......	......	......	......	25.	25.	......	......	......	......
Bronze, red	87.	13.	......	......	......	......	......	......	......	......	......
“ red	86.	11.1	2.9	......	......	......	......	......	......	......	......
“ yellow	67.2	31 2	1.6	......	......	......	......	......	......	......	......
“ Cymbals	80.	......	20.	......	......	......	......	......	......	......	......
“ gun metal, large	90.	......	10.	......	......	......	......	......	......	......	......
“ “ small	93.	......	7.	......	......	......	......	......	......	......	......
“ Medals	93.	......	7.	......	......	......	......	......	......	......	......
“ Statuary	91.4	5.5	1.4	......	1.7	......	......	......	......	......	......
Chinese Silver	65.1	19.3	......	13.	......	......	......	2.48	.12	......	......
Chinese white copper	40.4	25.4	2.6	31.6	......	......	......	......	......	......	......
Church bells	80.	5.6	10.1	......	4.3	......	......	......	......	......	......
“	69.	......	31.	......	......	......	......	......	......	......	......
Clock bells	72.	......	26.5	......	......	......	......	......	......	1.5	......
Cocks, Musical bells	87.5	......	12.5	......	......	......	......	......	......	......	......
German silver	33.3	33.4	......	33,3	......	......	......	......	......	......	......
“ “	40.4	25.4	......	31.6	......	......	......	......	......	2.6	......
“ “ fine	49.5	24.	......	24.	......	......	......	......	......	2.5	......
Gongs	81.6	......	18.4	......	......	......	......	......	......	......	......
House bells	77.	......	23.	......	......	......	......	......	......	......	......
Lathe bushes	80.	......	20.	......	......	......	......	......	......	......	......
Machinery bearings	87.5	......	12.5	......	......	......	......	......	......	......	......
“ “ hard	77.4	7.	15.6	......	......	......	......	......	......	......	......
Metal that expands in cooling	......	......	......	......	75.	16.7	8.3	......	......	......	......
Muntz metal	60.	40.	......	......	......	......	......	......	......	......	......
Pewter, best	......	......	86.	......	......	14.	......	......	......	......	......
“	......	......	80.	......	20.	......	......	......	......	......	......
Printing characters	......	......	......	......	80.	20.	......	......	......	......	......
Sheathing metal	56.	45.	......	......	......	......	......	......	......	......	......
Speculum “	66.	......	22.	......	......	......	......	......	......	......	12.
“ “	50.	21.	29.	......	......	......	......	......	......	......	......
Telescopic mirrors	66.6	......	33.4	......	......	......	......	......	......	......	......
Temper†	33.4	......	66.6	......	......	......	......	......	......	......	......
Type and stereotype plates	......	......	......	......	69.	15.5	15.5	......	......	......	......
White metal	7.4	7.4	28.4	......	......	56.8	......	......	......	......	......
“ “ hard	69.8	25.8	4.4	......	......	......	......	......	......	......	......
Oreide	73.	12.3	{ Magnesia......... 4.4 Cr'm of tartar 6.5 { Sal-ammoniac 2.5 Quick-lime 1.33								

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*See page 164 for directions. †For adding small quantities of copper.

RARE AND VALUABLE RECEIPTS AND TABLES FOR MECHANICAL PURPOSES.

Yellow Brass, for Turning.—(Common article.)—Copper, 20 lbs.; zinc, 10 lbs.; lead from 1 to 5 oz. Put in the lead last before pouring off.

Red Brass, for Turning.—Copper, 24 lbs.; zinc, 5 lbs., lead, 8 oz. Put in the lead last before pouring off.

Red Brass, free, for Turning.—Copper, 160 lbs.; zinc, 50 lbs.; lead, 10 lbs.; antimony, 44 oz.

Another Brass, for Turning.—Copper, 32 lbs.; zinc, 10 lbs; lead, 1 lb.

Best Red Brass, for Fine Castings.—Copper, 24 lbs.; zinc, 5 lbs.; bismuth, 1 oz. Put in the bismuth last before pouring off.

Bronze Metal.—Copper, 7 lbs.; zinc, 3 lbs.; tin, 2 lbs.

Bronze Metal.—Copper, 1 lb.; zinc, 12 lbs.; tin, 8 lbs.

Bell Metal, for Large Bells.—Copper, 100 lbs.; tin, from 20 to 25 lbs.

Bell Metal, for Small Bells.—Copper, 3 lbs.; tin, 1 lb.

Cock Metal.—Copper, 20 lbs.; lead, 8 lbs.; litharge, 1 oz.; antimony, 3 oz.

Hardening for Britannia.—(To be mixed separately from the other ingredients.)—Copper, 2 lbs.; tin, 1 lb.

Good Britannia Metal.—Tin, 150 lbs.; copper, 3 lbs.; antimony, 10 lbs.

Britannia Metal, second Quality.—Tin, 140 lbs.; copper, 3 lbs.; antimony, 9 lbs.

Britannia Metal, for Casting.—Tin, 210 lbs.; copper, 4 lbs.; antimony, 12 lbs.

Britannia Metal, for Spinning.—Tin, 100 lbs.; Britannia hardening, 4 lbs.; antimony, 4 lbs.

White Solder, for Raised Britannia Ware.—Tin, 100 lbs.; copper, 3 oz., to make it free; and lead, 3 oz.

Britannia Metal, for Registers.—Tin, 100 lbs.; hardening, 8 lbs.; antimony, 8 lbs.

Best Britannia, for Spouts.—Tin, 140 lbs.; copper 3 lbs.; antimony, 6 lbs.

Best Britannia, for Spoons.—Tin, 100 lbs.; hardening, 5 lbs.; antimony, 10 lbs.

Best Britannia, for Handles.—Tin, 140 lbs.; copper, 2 lbs.; antimony 5 lbs.

Best Britannia, for Lamps, Pillars and Spouts.—Tin, 300 lbs.; copper, 4 lbs.; antimony, 15 lbs.

Casting.—Tin, 100 lbs.; hardening, 5 lbs.; antimony, 5 lbs.

Lining Metal, for Boxes of Railroad Cars.—Mix tin, 24 lbs.; copper, 4 lbs.; antimony, 8 lbs. (for a hardening); then add tin, 72 lbs.

Fine Silver Colored Metal.—Tin, 100 lbs.; antimony, 8 lbs.; copper, 4 lbs.; bismuth, 1 lb.

German Silver, First Quality, for Casting.—Copper, 50 lbs.; zinc, 25 lbs.; nickel, 25 lbs.

German Silver, Second Quality, for Casting.—Copper, 50 lbs.; zinc, 20 lbs.; nickel (best pulverized), 10 lbs.

German Silver, for Rolling.—Copper, 60 lbs.; zinc, 20 lbs.; nickel, 25 lbs.

German Silver, for Bells and other Castings.—Copper, 60 lbs.; zinc, 20 lbs.; nickel, 20 lbs.; lead, 3 lbs.; iron (that of tin plate being best,) 2 lbs.

Imitation of Silver.—Tin, 3 oz.; copper, 4 lbs.

Pinchbeck.—Copper, 5 lbs.; zinc, 1 lb.

Tombac.—Copper, 16 lbs.; tin, 1 lb.; zinc, 1 lb.

Red Tombac.—Copper, 10 lbs.; zinc, 1 lb.

Hard White Metal.—Sheet brass, 32 oz.; lead, 2 oz.; tin, 2 oz.; zinc, 1 oz.

Metal for taking Impressions.—Lead, 3 lbs.; tin, 2 lbs.; bismuth, 5 lbs.

Spanish Tutania.—Iron or steel, 8 oz.; antimony, 16 oz.; nitre, 3 oz. Melt and harden 8 oz. tin with 1 oz. of the above compound.

Rivet Metal.—Copper, 32 oz.; tin, 2 oz.; zinc, 1 oz.

Rivet Metal, for Hose.—Tin, 64 lbs.; copper, 1 lb.

Fusible Alloy.—(Which melts in boiling water).—Bismuth, 8 oz.; tin, 3 oz.; lead, 5 oz.

Fusible Alloy, for Silvering Glass.—Tin, 6 oz., lead, 10 oz.; bismuth, 21 oz.; mercury, a small quantity.

Best Soft Solder for Cast Britannia Ware.—Tin, 8 lbs.; lead, 5 lbs.

Yellow Solder, for Brass or Copper.—Copper, 32 lbs.; zinc, 29 lbs.; tin, 1 lb.

Brass Solder.—1. Copper, 61.25 parts; zinc, 38.75 parts; 2. (Yellow and easily fusible) copper, 45 parts; zinc, 55 parts; 3. (White) copper, 57.41 parts, tin, 14.60 parts; zinc, 27.99 parts.

Solder, for Copper,—Copper, 10 lbs.; zinc, 9 lbs.

Black Solder.—Copper, 2 lbs.; zinc, 3 lbs.; tin, 2 oz.

Black Solder.—Sheet brass, 20 lbs.; tin, 6 lbs.; zinc, 1 lb.

Soft Solder.—Tin, 15 lbs.; lead, 15 lbs.

Pewterer's Soft Solders.—1. Bismuth, 2; lead, 4; tin, 3. 2. Bismuth, 1; lead, 1; tin, 2.

Plumber's Solder.—Lead, 3 parts; tin, 1 part.

Solder.—For lead, the solder is one part tin, 1 to 2 of lead; for tin, 1 to 2 parts tin to 1 of lead; for zinc, 1 part tin to 1 to 2 of lead; for pewter, 1 part tin to 1 of lead, and 1 to 2 parts of bismuth.

The surfaces to be joined are made perfectly clean and smooth, and then covered with sal ammoniac, or resin, or both; the solder is then applied, being melted in, and smoothed over by the soldering iron.

Coppersmith's Cement, &c.—Bullock's blood thickened with finely-powdered lime. Use as soon as mixed, as it rapidly gets hard. Coppersmith's solder.—Tin 2 parts, lead 1 part. When the copper is thick, heat it by a naked fire; if thin, use a tinned copper tool. Use muriate or chloride of zinc, or resin, as a flux. The same solder will do for iron, cast iron, or steel; if thick, heat by a naked fire, or immerse in the solder.

Solder for Gold.—Gold, 6 dwts.; silver, 1 dwt.; copper, 2 dwts.

Soft Gold Solder.—Gold, 4 parts; silver, 1 part; copper, 1 part.

Solder for Silver.—(For the use of jewellers.)—Fine silver, 19 dwts.; copper, 1 dwt., sheet brass, 10 dwts.

White Solder, for Silver.—Silver, 1 oz.; tin, 1 oz.

Silver Solder, for Plated Metal.—Fine silver, 1 oz.; brass, 10 dwts.

Solders.—For Steel Joints. Silver, 19 parts; copper, 1 part; brass, 2 parts; melt altogether.

Hard Solder.—Copper, 2 parts; zinc, 1 part; melt together.

For Gold.—1. Silver, 7 parts; copper, 1 part, with borax. 2. Gold, 2 parts; silver, 1 part; copper, 1 part. 3. Gold, 3 parts; silver, 3 parts; copper, 1 part; zinc, ½ part.

For Silver.—Silver, 2 parts; brass, 1 part, with borax; or, silver, 4 parts; brass, 3 parts; zinc, 1-16, with borax.

For Brass.—Copper, 3 parts; zinc, 1 part, with borax.

For Platina.—Gold, with borax.

For Iron.—The best solder for iron is good tough brass, with a little borax.

For Copper.—Brass, 6 parts; zinc, 1 part; tin, 1 part; melt all together, mix well, and pour out to cool.

Gold Solders.—1. Copper, 24.24 parts; silver, 27.57 parts; gold, 48.19 parts. 2. Enamel solder—Copper, 25 parts; silver, 7.07 parts; gold, 67.93 parts. 3. Copper, 26.25 parts; zinc, 6.25 parts; silver, 31.25 parts; gold, 36.25 parts. 4. Enamel solder—Silver, 19.57 parts; gold, 80.43 parts.

Solders.—For 22 carat gold—Gold of 22 carats, 1 dwt.; silver, 2 gr.; copper, 1 gr.

For 18 carat gold—Gold of 18 carats, 1 dwt.; silver, 2 gr.; copper, 1 gr.

For cheaper gold—Gold, 1 dwt.; silver, 10 gr.; copper, 8 gr.

Cheaper still—Fine gold, 1 dwt.; silver, 1 dwt.; copper, 1 dwt.

Silver Solders.—1. (*hard.*) Copper, 30 parts; zinc, 12.85 parts; silver, 57.15 parts. 2. Copper, 23.33 parts; zinc, 10.00 parts; silver, 66.67 parts. 3, Copper, 26.66 parts; zinc, 10.00 parts; silver, 63.34 parts. 4. (*soft.*) Copper, 14.75 parts; zinc, 8.20 parts; silver, 77.05 parts. 5. Copper, 22.34 parts; zinc, 10.48 parts; silver, 67.18 parts. 6. Tin, 63.00 parts; lead, 37 parts.

Colored Gold.—1. Full red gold.—Gold, 5 dwt.; copper, 5 dwt. 2. Red gold.—Gold, 10 dwt.; silver, 1 dwt.; copper, 4 dwt. 3. Green gold.—Gold, 5 dwt.; silver, 21 gr. 4. Gray gold.—Gold, 3 dwt. 15 gr.; silver, 1 dwt. 9 gr. 5. Blue gold.—Gold, 5 dwt.; steel filings, 5 dwt. 6. Antique gold, greenish-yellow.—Gold, 18 dwt. 9 gr.; silver, 21 gr.; copper, 18 gr. These all require to be submitted to the process of wet-coloring. 7. Factitious gold, very bright.—Copper, 16 parts; platina, 7 parts; zinc, 1 part; fused together.

Alloys for Gold.—1. Red gold.—Copper, 66.67 parts; gold 33.33 parts. 2. Yellow gold.—Copper, 12.50 parts; silver, 37.50 parts; gold, 50 parts. 3 Green gold.—Silver, 25 parts; gold, 75 parts. 4. Yellow gold.—Silver, 66.67 parts; gold, 33.33, parts; 5. Gray gold.—Silver, 5.89 parts; gold, 88.23 parts; iron, 5.89 parts. 6. Dentists' gold.—Silver, 8.34 parts; platinum, 66.67 parts; gold, 24.29 parts. 7. English gold coin.—Copper, 8.34 parts; gold, 91.66 parts. 8. American gold coin.—Copper, 10 parts; gold, 90 parts. French gold coin same as American.

Alloys for Silver Coin and Plate.—1. English standard. —Copper, 7.50 parts; silver, 92.50 parts. 2. American standard. —Copper, 10 parts; silver, 90 parts. French the same.

Gilding Metal for common jewelry is made by mixing 4 parts copper with one of calamine brass. Sometimes 1 lb. copper with 6 oz. of brass.

Jeweller's Gold Compositions, Common Gold.—Silver, 1 part; Spanish copper, 16 parts; gold, 2 parts; mix. Ring gold.—Spanish copper, 6 parts; silver, 3 parts; gold, 5 parts; mix. Manheim gold —Copper, 3 parts; zinc, 1 part; melt, and stir well. Mosaic gold.—Copper and zinc, equal parts; melt at the lowest temperature that will fuse the former, then mix by stirring, and add 5 per cent. more zinc. Parker's mosaic gold.—Copper, 100 parts; zinc 54 parts; mix. For common jewelry.—Copper, 3 parts; 1 of old brass, and 4 oz. of tin to every pound of copper.

Factitious Gold.—Copper, 16 parts; platinum, 7 parts; zinc, 1 part; fused together. This alloy resembles gold of 16 carats fine, or ⅔, and will resist the action of nitric acid, unless very concentrated and boiling.

Harmstadt's True Imitation of Gold is stated not only to resemble gold in color, but also in specific gravity and ductility. Platinum, 16 parts; copper, 7 parts; zinc, 1 part; put in a crucible, cover with charcoal powder, and melt into a mass.

Do. of Silver.—Copper, ¼ oz.; brass, 2 oz.; pure silver, 3 oz.; bismuth, 2 oz.; saltpetre, 2 oz.; common salt, 1 oz.; arsenic, 1 oz.; potash, 1 oz.; melt in a crucible with powdered charcoal. This compound was used by a German chemist for unlawful purposes to the amount of thousands, and is so perfect that he was never discovered.

Artificial Gold.—This is a new metallic alloy which is now very extensively used in France as a substitute for gold. Pure copper, 100 parts; zinc, or, preferably, tin, 17 parts; magnesia, 6 parts; sal-ammoniac, 3-6 parts; quick-lime, ⅛ part; tartar of commerce, 9 parts; are mixed as follows: The copper is first melted, and the magnesia, sal-ammoniac, lime, and tartar are then added, separately, and by degrees, in the form of powder. The whole is now briskly stirred for about half an hour, so as to mix thoroughly; and then the zinc is added in small grains by throwing it on the surface, and stirring till it is entirely fused; the crucible is then covered, and the fusion maintained for about thirty-five minutes. The surface is then skimmed, and the alloy is ready for casting.

It has a fine grain, is malleable, and takes a splendid polish. It does not corrode readily, and, for many purposes, is an excellent substitute for gold. When tarnished, its brilliancy can be restored by a little acidulated water. If tin be employed instead of zinc, the alloy will be more brilliant. It is very much used in France, and must ultimately attain equal popularity here.

New French Patent Alloy for Silver.—Messieurs DeRuolz & Fontenay have invented the following alloy, which may be used for almost all purposes for which silver is usually employed: Silver, 20 parts; purified nickel, 28 parts; copper, 52 parts. Melt the copper and nickel in the granular state, then introduce the silver. The flux to be employed is charcoal and borax, both in the state of powder; and the ingots obtained are to be rendered malleable by annealing for a considerable time in powdered charcoal.

Alloys for Gold.—22 parts gold, 2 parts copper, is 22 carats fine; 20 parts gold, and 4 parts copper, is 20 carats fine; 18 parts gold, and 6 parts copper, is 18 carats fine.

English Standard for Silver.—Pure silver, 11 oz. 2 dwts.; copper, 22 dwts. Melt.

Silver Imitations.—Copper 1 lb.; tin, ¾ oz.; melt. This composition will roll and ring very near to silver. BRITANNIA METAL.—Copper, 1 lb.; tin, 1 lb.; regulus of antimony, 2 lbs.; melt together, with or without a little bismuth. GENUINE GERMAN SILVER.—Iron, 2½ parts; nickel, 31½ parts; zinc, 25½ parts; copper, 40½ parts; melt. FINE WHITE GERMAN SILVER.—Iron, 1 part; nickel, 10 parts; zinc, 10 parts; copper, 20 parts; melt. PINCH-

BECK.—Copper, 5 parts; zinc, 1 part; melt the copper, then add the zinc. JEWELLER'S METAL.—Copper, 30 parts; tin, 7 parts; brass, 10 parts. Mix.

French Gold Plate.—1. Gold, 92 parts; copper, 8 parts. 2. Gold, 84 parts; copper, 16 parts. 3. Gold, 75 parts; copper, 25 parts.

Bidery.—Copper, 48.48 parts; tin, 6.60 parts; zinc, 33.80 parts; lead, 12.12 parts.

Best Brass for Clocks.—Rose copper, 85 parts; zinc, 14 parts; lead, 1 part.

Alloy for Watch Pinion Sockets.—Gold, 31 parts; silver, 19 parts; copper, 39 parts; palladium, 1 part.

To Reduce Hair-Springs.—Immerse the springs about 2 or 3 seconds in nitric acid, 3 drops to one teaspoonful of water. By this means you can reduce them to any extent. It requires very careful manipulation, experience, and good judgment.

Albata Metal.—Nickel, 3 to 4 parts; copper, 20 parts; zinc, 16 parts. Used for plated goods.

British Plate.—Nickel, 5 to 6 parts; copper, 20 parts; zinc, 8 to 10 parts. Used for plated goods.

Chantry's Hard Alloy.—Copper, 1 lb.; zinc, 2½ oz.; tin, 2½ oz. Razors as hard as tempered steel have been made from this alloy.

Hard White Metal for Buttons.—Brass, 1 lb.; zinc, 2 oz.; tin, 1 oz.

Birmingham Platin.—Copper, 8 parts; zinc, 5 parts.

German Silver.—1. Copper, 40.62 parts; zinc, 43.76 parts; nickel, 15.62 parts. 2. Copper, 41.47 parts; zinc, 26.08 parts; nickel, 32.45 parts. 3. Copper, 55.55 parts; zinc, 5.55 parts; nickel, 38.90 parts. 4. Copper, 53.40 parts; zinc, 29.10 parts; nickel, 17.50 parts. 5. (*Alfenide* contains a trace of iron.) Copper, 59.60 parts; zinc, 30.30 parts; nickel, 10.10 parts.

Britannia Metal.—1. Copper, 0.30 parts; tin, 89.70 parts; zinc, 0.30 parts; antimony, 9.70 parts. 2. Copper, 1.85 parts; tin, 81.64 parts; antimony, 16.51 parts. 3. Copper, 0.91 parts; tin, 89.97 parts; antimony, 9.12 parts. 4. Tin, 90.00 parts; antimony, 10 parts. 5. Copper, 1.78 parts; tin; 89.30 parts; antimony, 7.14 parts; bismuth, 1.78 parts.

Gun Metal.—Copper, 90 parts; tin, 10 parts.

Melting Point of Metals.—Iron fuses at 2787° Fahr.; gold at 2016°; silver, 1873°; copper, 1996°; zinc, 773°; antimony, 809°; bismuth, 476° to 507°; nickel, 630°; tin, 442°; lead, 334°; mercury volatilizes at 670°.

Chinese Gong Metal.—Copper, 78.00 parts; tin, 22.00.

Alloy for Gun Mountings.—Copper, 80 parts; tin, 3; zinc, 17.

Bell Metal.—1. Copper, 60 parts; tin, 40 parts. 2. Copper, 80 parts; tin, 20 parts. 3. (*Thomson's*) Copper, 80 parts; tin, 10.10 parts; zinc, 5.60 parts; lead, 4.30 parts.

White Metal for Table Bells.—Copper 2.06 parts, tin 97.31 parts, bismuth 0.63 parts.

Clock Bell Metal.—Copper 75.19 parts, tin 48.81 parts.

Socket Metal for Locomotive Axle-trees.—1. Copper 86.03, tin 13. 97; 2. (*French*) Copper 82 parts, tin 10 parts, zinc 8 parts; 3. (*Stephenson's*) Copper 79 parts, tin 8 parts, zinc 5 parts, lead 8 parts; 4. (*Belgian*) Copper 89.02 parts, tin 2.44 parts, zinc 7.76 parts iron, 0.78 parts; 5. (*English*) Copper, 73.96 parts, tin, 9.49 parts, zinc, 9.03 parts, lead, 7.09 parts, iron, 0.43 parts.

Brass.—1. Copper 73 parts, zinc 27 parts; 2. Copper 65 parts, zinc 35 parts; 3. Copper 70 parts; zinc 30 parts.

Alloy for Mechanical Instruments.—Copper 1 lb., tin 1 oz.

Malleable Brass.—1. Copper 70.10 parts, zinc 29.90 parts· 2. (*Superior*) Copper 60 parts, zinc 40 parts.

Button Maker's Metal.—1. Copper 43 parts, zinc 67 parts; 2. Copper 62.22 parts, tin 2.78 parts, zinc 35.00 parts.

Metal for Sliding Levers of Locomotives.—1. Copper 85.25 parts, tin 12.75 parts, zinc 2.00 parts; 2. (*Fenton's*) Copper 5.50 parts, tin 14.50 parts, zinc 80 parts.

Alloy for Cylinders of Locomotives.—Copper 88.63 parts, tin 2.38 parts, zinc 6.99 parts.

Alloy for Stuffing Boxes of Locomotives.—Copper 90.06 parts, tin 3.56 parts, zinc 6.38 parts.

Amalgam for Mirrors.—1. Tin 70 parts, mercury 30 parts; 2, (*For curved mirrors*) tin 80 parts, mercury 20 parts; 3. Tin 8.33 parts, lead 8.34 parts, bismuth 8.33 parts, mercury 75 parts; 4. (*For spherical mirrors*) Bismuth 80 parts, mercury 26 parts.

Reflector Metal.—1. (*Duppler's*) Zinc 20 parts, silver 80 parts, 2. Copper 66.22 parts, tin 33.11 parts, arsenic 0.67 parts; 3. (*Cooper's*) Copper 57.86 parts, tin 27.28 parts, zinc 3.30 parts, arsenic 1.65 parts, platinum 9.91 parts; 4. Copper 64 parts, tin 32.00 parts, arsenic 4.00 parts; 5. Copper 82.18 parts, lead 9.22 parts, antimony 8.60 parts; 6. (*Little's*) Copper 69.01 parts, tin 30.82 parts, zinc 2.44 parts, arsenic 1.83 parts.

Metal for Gilt Wares.—1. Copper 78,47 parts, tin 2.87 parts, zinc 17.23 parts, lead 1.43 parts; 2. Copper 64.43 parts, tin 0.25 parts, zinc 32.44 parts, lead 2.86 parts; 3. Copper 72.43 parts, tin 1.87 parts, zinc 22.75 parts, lead 2.96 parts; 4. Copper 70.90 parts, tin 2.00 parts, zinc 24.05 parts, lead 3.05 parts.

Spurious Silver Leaf.—Tin 90.00 parts, zinc 9.91 parts.

Shot Metal.—1. Lead 97.07 parts, arsenic 2.93 parts; 2. Lead 99.60 parts, arsenic 0.40 parts.

Bismuth Solder.—Tin, 33.33 parts; lead, 33.33 parts, bismuth, 33.34 parts.

Alloy for Calico Printing Blocks.—Tin, 50.00 parts; lead, 33.34; bismuth, 16.66 parts.

Amalgam for Electrical Machines.—1. Tin, 25 parts; zinc, 25 parts; mercury, 50 parts; 2. Tin, 11.11 parts; zinc, 22.22 parts; mercury, 66.67 parts.

Type Metal.—1. (*For smallest and most brittle types*) Lead, 3; antimony, 1; 2. (*For small, hard, brittle types*) Lead, 4; antimony, 1; 3. (*For types of medium size*) Lead, 5; antimony, 1; 4. (*For large types*) Lead, 6; antimony, 1; 5. (*For largest and softest types*) Lead, 7; antimony, 1. In addition to lead and antimony, type metal also contains 4 to 8 per cent. of tin, and sometimes 1 to 2 per cent. of copper. Stereotype plates are made of lead, 20 parts; antimony, 4 parts; tin, 1 part.

Brass for Wire.—Copper, 34 parts; calamine, 56 parts; mix.

Britannia Metal.—1. Tin, 82 parts; lead, 18 parts; brass, 5 parts; antimony 5 parts; mix. 2. Brass, 1 part; antimony, 4 parts; tin, 20 parts; mix. 3. Plate-brass, tin, bismuth, and antimony, of each equal parts. Add this mixture to melted tin until it acquires the proper color and hardness.

Bronze.—1. Copper, 83 parts; zinc, 11 parts; tin, 4 parts; lead, 2 parts; mix. 2. Copper, 14 parts; melt, and add zinc, 6 parts; tin, 4 parts; mix.

Ancient Bronze.—Copper, 100 parts; lead and tin, each 7 parts; mix.

Alloy for Bronze Ornaments.—Copper, 82 parts; zinc, 18 parts; tin, 3 parts: mix.

Beautiful Red Bronze Powder.---Sulphate of copper, 100 parts; carbonate of soda, 60 parts; apply heat until they unite into a mass; then cool, and add copper-filings, 15 parts. Well mix, and keep them at a white heat for 20 minutes; then cool, powder, wash and dry.

Bronzing Fluid for Guns.—Nitric acid, sp. gr. 1.2; nitric ether, alcohol, murate of iron, each 1 part; mix, then add sulphate of copper, 2 parts, dissolved in water, 10 parts.

Cannon Metal.—Take tin, 10 parts; copper, 90 parts; melt.

Statuary Bronze.—1. Copper, 88 parts; tin, 9 parts; zinc, 2 parts; lead, 1 part. 2. Copper, 82½ parts; tin, 5 parts; zinc, 10½ parts; lead, 2 parts. 3. Copper, 90 parts; tin, 9 parts; lead, 1 part.

Bronze for Medals.—Copper, 89 parts; tin, 8 parts; zinc, 3 parts.

Bronze for Large Cannon.—Copper, 90; tin, 7.

Bronze for Small Cannon.—Copper, 93; tin, 7.

Alloy for Symbals.—Copper, 80; tin, 20.

Mirrors of Reflecting Telescopes.—Copper, 100; tin, 50.

White Argentine.—Copper, 8; nickel, 3; zinc, 35. This beautiful composition is in imitation of silver.

Chinese Silver.—Silver, 2.5; copper, 65.24; zinc, 19.52; cobalt of iron, 0.12; nickel, 13.

Tutenag.—Copper, 8; nickel, 3; zinc, 5.

Printing Characters.—Lead, 4; antimony, 1. For stereotype plates, lead, 25; antimony, 4; tin, 1.

Fine White German Silver.—1. *For Castings.* Lead, 3 parts; nickel, 20 parts; zinc 20 parts; copper, 60 parts; mix. 2. *For Rolling.* Nickel, 5 parts; zinc, 4 parts; copper, 12 parts; mix.

Imitation Platinum.—Melt together 8 parts brass and 5 of zinc. This alloy very closely resembles platinum.

Imitation Gold.—Platina, 8 parts; silver, 4 parts; copper, 12 parts; melt all together.

Imitation Silver.—Block-tin, 100 parts; antimony, 8 parts; bismuth, 1 part; copper, 4 parts; melt all together.

Tombac, or Red Brass.—Melt together, 8 parts of copper and 1 part of zinc.

Parisian Bell Metal.—Copper, 72 parts; tin, 26½ parts; iron, 1½ parts; used for the bells of small ornamental clocks.

Bell Metal.—1. Copper, 25 parts; tin, 5 parts; mix. 2. Copper, 79 parts; tin, 26 parts; mix. 3. Copper, 78 parts; tin, 22 parts; mix.

Prince's Metal.—1. Copper, 3 parts; zinc, 1 part. 2. Brass, 8 parts; zinc, 1 part. 3. Zinc and copper, equal parts : mix.

Queen's Metal.—1. Lead, 1 part; bismuth, 1 part; antimony, 1 part; tin, 9 parts; mix. 2. Tin, 9 parts; bismuth, 1 part; lead, 2 parts; antimony, 1 part, mix by melting.

Brass.—Copper, 3 parts; melt, then add zinc 1 part.

Button-Maker's Fine Brass.—Brass, 8 parts; zinc 5 parts.

Button-Maker's Common Brass.—Button-brass, 6 parts; tin, 1 part; lead, 1 part; mix.

Fine Brass.—Copper, 2 parts; zinc, 1 part; mix.

Organ Pipes consist of lead alloyed with about half its quantity of tin to harden it. The mottled or crystalline appearance so much admired shows an abundance of tin.

Baron Wetterstedt's Patent Sheathing for ships consists of lead, with from 2 to 8 per cent. of antimony; about 3 per cent. is the usual quantity. The alloy is rolled into sheets.

Lead Pipes are cast as hollow cylinders, and drawn out upon triblets; they are also cast of any length without drawing.

Lead Shot are cast by letting the metal run through a narrow slit into a species of colander at the top of a lofty tower; the metal escapes in drops, which, for the most part, assume the spherical form before they reach the tank of water into which they fall at the foot of the tower, and this prevents their being bruised. They are afterwards riddled or sifted for size, and afterwards churned in a barrel with black lead.

Metal for Anatomical Injections.—Tin, 16.41 parts; lead, 9.27 parts; bismuth, 27.81 parts; mercury, 46.41 parts.

Yellow Dipping Metal.—Copper, 32 lbs.; 6 to 7 oz. zinc to every lb. of copper.

Quick Bright Dipping Acid, for Brass which has been Ormolued.—Sulphuric acid, 1 gal.; nitric acid, 1 gal.

Dipping Acid.—Sulphuric acid, 12 lbs.; nitric acid, 1 pint; nitre, 4 lbs.; soot, 2 handfuls; brimstone, 2 oz. Pulverize the brimstone, and soak it in water an hour. Add the nitric acid last.

Good Dipping Acid for Cast Brass.—Sulphuric acid, 1 qt.; nitre, 1 qt.; water, 1 qt. A little muriatic acid may be added or omitted.

Dipping Acid.—Sulphuric acid, 4 gals.; nitric acid, 2 gals.; saturated solution of sulphate of iron (copperas,) 1 pint; solution of sulphate of copper, 1 qt.

Ormolu Dipping Acid, for Sheet Brass.—Sulphuric acid, 2 gals.; nitric acid, 1 pt.; muriatic acid, 1 pt.; water, 1 pint.; nitre, 12 lbs. Put in the muriatic acid last, a little at a time, and stir the mixture with a stick.

Ormolu Dipping Acid, for Sheet or Cast Brass.—Sulphuric acid, 1 gal.; sal ammoniac, 1 oz.; sulphur (in flour,) 1 oz.; blue vitriol, 1 oz.; saturated solution of zinc in nitric acid, mixed with an equal quantity of sulphuric acid, 1 gal.

To Prepare Brass Work for Ormolu Dipping.—If the work is oily, boil it in lye; and if it is finished work, filed or turned, dip it in old acid, and then it is ready to be ormolued; but if it is unfinished, and free from oil, pickle it in strong sulphuric acid, dip in pure nitric acid, and then in the old acid, after which it will be ready for ormoluing.

To Repair Old Nitric Acid Ormolu Dips.—If the work after dipping appears coarse and spotted, add vitriol till it answers the purpose. If the work after dipping appears too smooth, add muriatic acid and nitre till it gives the right appearance.

The other ormolu dips should be repaired according to the receipts, putting in the proper ingredients, to strengthen them. They should not be allowed to settle, but should be stirred often while using.

Tinning Acid, for Brass or Zinc.—Muriatic acid, 1 qt.; zinc, 6 oz. To a solution of this, add water, 1 qt; sal ammoniac, 2 oz.

Vinegar Bronze, for Brass.—Vinegar, 10 gals.; blue vitriol, 3 lbs.; muriatic acid, 3 lbs.; corrosive sublimate, 4 grs.; sal ammoniac, 2 lbs.; alum, 8 oz.

Directions for making Lacquer.—Mix the ingredients, and let the vessel containing them stand in the sun, or in a place slightly warmed, three or four days, shaking it frequently till the gum is dissolved, after which, let it settle from twenty-four to forty-eight hours, when the clear liquor may be poured off for use. Pulverized glass is sometimes used, in making lacquer, to carry down the impurities.

Lacquer, for Dipped Brass.—Alcohol, proof specific gravity not less than 95-100ths, 2 gals.; seed lac, 1 lb.; gum copal 1 oz.; English saffron, 1 oz.; annotto, 1 oz.

Lacquer for Bronzed Brass.—To one pint of the above lacquer, add gamboge, 1 oz.; and, after mixing it, add an equal quantity of the first lacquer.

Deep Gold-Colored Lacquer. — Best alcohol, 40 oz.; Spanish annotto, 8 grs.; turmeric, 2 drs.; shellac, ½ oz.; red sanders, 12 grs.; when dissolved, add spirits of turpentine, 30 drops.

Gold-Colored Lacquer, for Brass not Dipped.—Alcohol, 4 gals.; turmeric, 3 lbs.; gamboge, 3 oz.; gum sanderach, 7 lbs; shellac, 1½ lbs.; turpentine varnish, 1 pint.

Gold-Colored Lacquer, for Dipped Brass.—Alcohol, 36 oz.; seed lac, 6 oz.; amber, 2 oz.; gum gutta, 2 oz.; red sandal wood, 24 grs.; dragon's blood, 60 grs.; oriental saffron, 36 grs.; pulverized glass, 4 oz.

Gold Lacquer, for Brass. — Seed lac, 6 oz.; amber or copal, 2 oz.; best alcohol, 4 gals.; pulverized glass, 4 oz.; dragon's blood, 40 grs.; extract of red sandal wood obtained by water, 30 grains.

Lacquer for Dipped Brass.—Alcohol, 12 gals.; seed lac, 8 lbs.; turmeric, 1 lb. to a gallon of the above mixture; Spanish saffron, 4 oz. The saffron is to be added for bronze work.

Good Lacquer.—Alcohol, 8 oz.; gamboge, 1 oz.; shellac, 3 oz.; annotto, 1 oz.; solution of 3 oz. of seed lac in 1 pint of alcohol; when dissolved, add ½ oz. Venice turpentine, ¼ oz. dragon's blood, will make it dark; keep it in a warm place four or five days.

To Bronze Iron Castings. — Cleanse thoroughly, and afterwards immerse in a solution of sulphate of copper, when the castings will acquire a coat of the latter metal. They must be then washed in water.

Antique Bronze Paint.—Sal-ammoniac, 1 oz.; cream tartar, 3 oz.; common salt, 6 oz. Dissolve in 1 pint hot water, then add 2 oz. of nitrate of copper dissolved in ½ pint water, mix well, and apply it repeatedly to the article, in a damp situation, with a brush

To Fill Holes in Castings.—A mixture of putty and black lead is good, but a better method is a metal that expands in cooling: Lead, 9 parts; antimony, 2; and bismuth 1. To be melted and poured in.

Pale Lacquer for Tin Plate.—Best alcohol, 8 oz.; turmeric, 4 drs.; hay saffron, 2 scs.; dragon blood, 4 scs.; red sanders, 1 sc.; shellac, 1 oz. ; gum sanderach, 2 drs. ; gum mastic, 2 drs. ; Canada balsam, 2 drs.; when dissolved, add spirits of turpentine, 80 drops.

Red Lacquer, for Brass. — Alcohol, 8 gallons; dragon's blood, 4 lbs.; Spanish annotto, 12 pounds; gum sanderach, 13 pounds; turpentine, 1 gallon.

Pale Lacquer, for Brass.—Alcohol, 2 gals.; Cape aloes, cut small, 3 oz.; pale shellac, 1 lb.; gamboge, 1 oz.

Bronze Dip.—Sal-ammoniac, 1 oz.; salt of sorrel (binoxolate of potash), ¼ oz. dissolved in vinegar.

Parisian Bronze Dip.—Sal-ammoniac, ½ oz.; common salt, ½ oz.; spirits of hartshorn, 1 oz. dissolved in an English quart of vinegar. A good result will be obtained by adding ½ oz. of sal-ammoniac, instead of the spirits of hartshorn. The piece of metal, being well cleaned; is to be rubbed with one of these solutions, then dried by friction with a flesh brush.

Best Lacquer for Brass.—Alcohol, 4 gals.; shellac, 2 lbs.; amber gum, 1 lb.; copal, 20 oz.; seed lac, 3 lbs.; saffron, to color; pulverized glass, 8 oz.

Color for Lacquer.—Alcohol, 1 qt.; annotto, 4 oz.

Lacquer for Philosophical Instruments. — Alcohol, 80 oz.; gum gutta, 3 oz.; gum sandarac, 8 oz.; gum elemi, 8 oz.; dragon's blood, 4 oz.; seed lac, 4 oz.; terra merita, 3 oz.; saffron, 8 grs.; pulverized glass, 12 oz.

Brown Bronze Dip.—Iron scales, 1 lb.; arsenic, 1 oz.; muriatic acid, 1 lb.; zinc (solid), 1 oz. Let the zinc be kept in only while it is in use.

Green Bronze Dip.—Wine vinegar, 2 qts.; verditer green, 2 oz.; sal ammoniac, 1 oz.; salt, 2 oz.; alum, ½ oz. French berries, 8 oz.; boil the ingredients together.

Aqua-fortis Bronze Dip.—Nitric acid, 8 oz.; muriatic acid, 1 qt.; sal-ammoniac, 2 oz.; alum, 1 oz.; salt, 2 oz.; water, 2 gals. Add the salt after boiling the other ingredients, and use it hot.

Olive Bronze Dip, for Brass.—Nitric acid, 3 oz.; muriatic acid, 2 oz.; add titanium or palladium; when the metal is dissolved, add 2 gals. pure soft water to each pint of the solution.

Brown Bronze Paint, for Copper Vessels.—Tincture of steel, 4 oz.; spirits of nitre, 4 oz.; essence of dendi, 4 oz.; blue vitriol, 1 oz.; water, ½ pint. Mix in a bottle; apply it with a fine brush, the vessel being full of boiling water; varnish after the application of the bronze.

Bronze for All Kinds of Metal.—Muriate of ammonia (sal-ammoniac), 4 drs.; oxalic acid, 1 dr.; vinegar, 1 pint. Dissolve the oxalic acid first; let the work be clean; put on the bronze with a brush, repeating the operation as many times as may be necessary.

Bronze Paint, for Iron or Brass.—Chrome green, 2 lbs.; ivory black, 1 oz.; chrome yellow, 1 oz.; good Japan, 1 gill: grind all together, and mix with linseed oil.

For Tinning Brass.—Water, 2 pails full; cream of tartar, ½ lb.; salt, ½ pint.

Shaved or Grained Tin.—Boil the work in the mixture, keeping it in motion during the time of boiling.

Silvering by Heat.—Dissolve 1 oz. of silver in nitric acid; add a small quantity of salt; then wash it, and add sal ammoniac, or 6 oz. of salt and white vitriol; also, ¼ oz. of corrosive sublimate;

rub them together till they form a paste; rub the piece which is to be silvered with the paste; heat it till the silver runs, after which dip it in a weak vitriol pickle to clean it.

Mixture for Silvering.—Dissolve 2 oz. of silver with 3 grs. of corrosive sublimate; add tartaric acid, 4 lbs.; salt, 8 qts.

Separate Silver from Copper.—Mix Sulphuric acid, 1 part; nitric acid, 1 part; water, 1 part; boil the metal in the mixture till it is dissolved, and throw in a little salt to cause the silver to subside.

Chinese White Copper.—Copper, 40.4; nickel, 31.6; zinc, 25.4; and iron, 2.6 parts.

Bath Metal.—Brass, 32; and zinc, 9 parts.

Speculum Metal.—Copper, 6; tin, 2; and arsenic, 1 part. Or copper, 7; zinc, 3; and tin, 4 parts.

Britannia Metal.—Brass, 4; tin, 4 parts; when fused, add bismuth, 4; and antimony, 4 parts. This composition is added at discretion to melted tin.

Jeweler's Soldering Fluid.—Take alcohol, and add to it all the chloride of zinc it will dissolve, and it is ready for use. A good *soft solder* for repairing,—equal quantities of tin, and lead from tea-boxes.

Tinman's Solder.—Lead, 1; tin, 1 part.

Pewterer's Solder.—Tin, 2; lead, 1 part.

Common Pewter.—Tin, 4; lead, 1 part.

Best Pewter.—Tin, 100; antimony, 17 parts.

Queen's Metal.—Tin, 9; antimony, 1; bismuth, 1; lead. 1 part.

Tinning Iron.—Cleanse the metal to be tinned; and rub with a coarse cloth, previously dipped in hydrochloric acid (muriatic acid,) and then rub on French putty with the same cloth. French putty is made by mixing tin filings with mercury.

Tinning.—1. Plates or vessels of brass or copper boiled with a solution of stannate of potassa, mixed with turnings of tin, become, in the course of a few minutes, covered with a firmly attached layer of pure tin. 2. A similar effect is produced by boiling the articles with tin-filings and caustic alkali, or cream of tartar. In the above way, chemical vessels made of copper or brass may be easily and perfectly tinned.

New Tinning Process.—The articles to be tinned are first covered with dilute sulphuric acid, and, when quite clean, are placed in warm water, then dipped in a solution of muriatic acid, copper, and zinc, and then plunged into a tin bath to which a small quantity of zinc has been added. When the tinning is finished, the articles are taken out and plunged into boiling water. The operation is completed by placing them in a very warm sand-bath. This last process softens the iron.

Kustitien's Metal for Tinning.—Malleable iron, 1 lb., heat to whiteness; add 5 oz. regulus of antimony, and Molucca tin, 24 pounds.

Watchmaker's Brass.—Copper, 1 part; zinc, 2 parts.

German Brass.—Copper, 1 part; zinc, 1 part.

Brass for Heavy Castings.—Copper, 6 to 7 parts; tin, 1 part; zinc, 1 part.

Yellow Brass.—(FOR CASTINGS).—1. Copper, 61.6 parts; zinc, 35.3 parts; lead, 2.9 parts; tin, 0.2 parts. 2. BRASS OF JEMAPPES.—Copper, 64.6 parts; zinc, 33.7 parts; lead, 1.4 parts; tin, 0.2 parts. 3. SHEET BRASS OF STOLBERG NEAR AIX-LA-CHAPELLE.—Copper, 64.8 parts; zinc, 32.8 parts; lead, 2.0 parts; tin, 0.4 parts. 4. D'ARCET'S BRASS FOR GILDING—Copper, 63.70 parts; zinc, 33.55 parts; lead, 0.25 parts; tin, 2.50 parts. 5. ANOTHER.—Copper, 64.45 parts; zinc, 32.44 parts; lead, 2.86 parts; tin, 0.25 parts. 6. SHEET BRASS OF ROMILLY.—Copper, 70.1 parts; zinc, 29.9 parts. 7. ENGLISH BRASS WIRE.—Copper, 70.29 parts; zinc, 29.26 parts; lead, 0.28 parts; tin, 0.17 parts. 8. AUGSBURG BRASS WIRE.—Copper, 71.89 parts; zinc, 27.63 parts; tin, 0.85 parts.

Red Brass for Gilt Articles.—1. Copper, 82.0 parts; zinc, 18.0 parts; lead, 1.5 parts; tin, 3.0 parts. 2. ANOTHER.—Copper, 82 parts; zinc, 18 parts; lead, 3 parts; tin, 1 part. 3. ANOTHER.—Copper, 82.3 parts; zinc, 17.5 parts; tin, 0.2 parts. 4. FRENCH TOMBAC FOR SWORD HANDLES.—Copper, 80 parts; zinc, 17 parts; tin, 3 parts. 5. FOR PARISIAN ORNAMENTS.—Copper, 85 parts; zinc, 15 parts; tin, a trace. 6. USED FOR GERMAN ORNAMENTS.—Copper, 85.3 parts; zinc, 14.7 parts. 7. CHRYSOCHALK.—Copper, 90.0 parts; zinc, 7.9 parts; lead, 1.6 parts. 8. RED TOMBAC FROM PARIS.—Copper, 92 parts; zinc, 8 parts.

Compositions.—1. FOR STRONG PUMPS, &C.—Copper, 1 lb.; zinc, ½ oz.; tin, 1½ oz. 2. FOR TOOTHED WHEELS.—Copper, 1 lb.; brass, 2 oz.; tin, 2 oz. 3. Copper, 1 lb.; brass, 2 oz.; tin, 1¾ oz. 4 FOR TURNING WORK.—Copper, 1 lb.; brass, 1½ oz.; tin, 2 oz. 5. FOR NUTS OF COARSE THREADS AND BEARINGS.—Copper, 1 lb.; brass, 1½ oz., tin, 2¼ oz. 6. FOR BEARINGS TO SUSTAIN GREAT WEIGHTS.—Copper, 1 lb.; zinc, ½ oz.; tin, 2½ oz. 7. PEWTERER'S TEMPER.—Tin, 2 lb.; copper, 1 lb. Used to add in small quantities to tin. 8. HARD BEARINGS FOR MACHINERY.—Copper, 1 lb.; tin, 2 oz. 9. VERY HARD DITTO.—Copper, 1 lb.; tin, 2½ oz.

Babbitt Metal.—Copper, 4 lbs.; regulus of antimony, 8 lbs.; Banca tin, 96 lbs.

Fenton's Anti-Friction Metal.—Grain zinc, 7½ lbs.; purified zince, 7½ lbs.; antimony, 1 lb.

Anti-Friction Alloy for Journal Boxes.—Zinc, 17 parts; copper, 1 part; antimony, 1½ parts. This possesses unsurpassable anti-friction qualities, and does not require the protection of outer casings of a harder metal.

Babbitt Metal.—Block tin, 8 lbs.; antimony, 2 lbs.; copper, 1 lb. If the metal be too hard, it may be softened by adding some lead.

Alloy for Journal Boxes.—The best alloy for journal boxes is composed of copper, 24 lbs.; tin, 24 lbs.; and antimony, 8 lbs. Melt the copper first, then add the tin, and lastly the antimony. It should be first run into ingots, then melted, and cast in the form required for the boxes.

To Gild Steel.—Pour some of the ethereal solution of gold into a wine glass, and dip into it the blade of a new penknife, razor, lancet, &c.; withdraw the instrument, and allow the ether to evaporate. The blade will then be found covered with a beautiful coat of gold. The blade may be moistened with a clean rag, or a small piece of very dry sponge, dipped into the ether; and the same effects will be produced.

To Weld Cast Iron.—Take of good clear white sand, 3 parts; refined solton, 1 part; fosterine, 1 part; rock salt, 1 part: mix all together. Take 2 pieces of cast iron, heat them in a moderate charcoal fire, occasionally taking them out while heating, and dipping them into the composition, until they are of a proper heat to weld; then at once lay them on the anvil, and gently hammer them together, and, if done carefully by one who understands welding iron, you will have them nicely welded together. One man prefers heating the metal, then cooling it in the water of common beans, and heat it again for welding.

To Galvanize Iron.—Cleanse the surface of the iron perfectly by the joint action of dilute acid and friction, plunge it into a bath of melted zinc covered with sal-ammoniac, and stir it about till it be alloyed superficially with this metal. When the metal thus prepared is exposed to humidity, the zinc oxidizes slowly by a galvanic action, and protects the iron within from rust; whereby the outer surface remains for a long time perfectly white, in circumstances under which iron tinned in the usual way would be corroded with rust.

Muntz Metal for Ships.—Best selected copper, 60 parts; best zinc, 40 parts: melt together in the usual manner, and roll into sheets of suitable thickness. This composition resists oxidation from exposure to sea water, and prevents the adhesion of barnacles.

Tempering Saws, &c.—The usual method of tempering saws is to heat, and then dip them in oil. This process is slow, costly, and laborious. It is also disadvantageous, because the saws become warped, and require to be hammered up straight again by hand. A late improvement consists in tempering and straightening the saws at one operation. This is done by heating the saws to the proper degree, and then pressing them with a sudden and powerful stroke between two surfaces of cold iron. A drop press is employed for the purpose. The mechanism is quite simple and inexpensive. Its use effects an important economy in the manufacture of nearly all kinds of saws, and also improves their quality.

Silvering Shells.—Silver leaf and gum water a sufficient quantity; grind to a proper thickness, and cover the inside of the shells.

For a *gold color*, grind up gold-leaf with gum water, and apply to the inside of the shells.

Liquid Foil for Silvering Glass Globes, &c. — Lead, 1 part; tin, 1 part; bismuth, 1 part: melt, and, just before it sets, add mercury, 10 parts. Pour this into the globe, and turn it rapidly round.

To Soften Iron or Steel.—Either of the following methods will make iron or steel as soft as lead:—1. Anoint it all over with tallow, temper it in a gentle charcoal fire, and let it cool of itself. 2. Take a little clay, cover your iron with it, temper in a charcoal fire. 3. When the iron or steel is red hot, strew hellebore on it. 4. Quench the iron or steel in the juice or water of common beans.

Tempering.—The article, after being completed, is hardened by being heated gradually to a bright red, and then plunged into cold water: it is then tempered by being warmed gradually and equably, either over a fire, or on a piece of heated metal, till of the color corresponding to the purpose for which it is required, as per table below; when it is again plunged into water.

CORRESPONDING TEMPERATURE.

A very pale straw,	430	Lancets.	
Straw,	450	Razors.	
Darker Straw	470	Penknives.	All kinds of wood tools.
Yellow,	490	Scissors.	Screw taps.
Brown yellow,	500	Hatchets, chipping chisels,	
Slightly tinged purple,	520	Saws.	
Purple,	530	All kinds of percussive tools.	
Dark purple,	550	Springs.	
Blue,	570		
Dark blue,	600	Soft for saws.	

Cast Iron Cement.—Clean borings or turnings of cast iron, 16; sal ammoniac, 2; flour of sulphur, 1 part; mix them well together in a mortar; and keep them dry. When required for use, take of the mixture, 1; clean borings, 20 parts; mix thoroughly, and add a sufficient quantity of water. A little grindstone dust added improves the cement.

Cement for Steam Pipe Joints, Etc., with Faced Flanges.—White lead, mixed, 2; red lead, dry, 1 part; grind, or otherwise mix them to a consistence of thin putty; apply interposed layers with one or two thicknesses of canvas, or gauze wire, as the necessity of the case may be.

Crucibles.—The best crucibles are made from a pure fire clay, mixed with finely ground *cement* of old crucibles, and a portion of black lead or graphite: some pounded coke may be mixed with the plumbago. The clay should be prepared in a similar way as for making pottery ware: the vessels, after being formed, must be slowly dried, and then properly baked in the kiln.

Black Lead Crucibles are made of 2 parts graphite, and 1 of fire-clay, mixed with water into a paste, pressed in moulds, and well dried, but not baked hard in the kiln. This compound forms excellent small or portable furnaces.

To Purify Gas.—The purifier is to be filled with milk of lime, made by mixing 1 part of slacked lime with 25 parts of water. A very great improvement in the purification of gas has been effected by Mr. Statter, of England, by the employment of hydrated clay along with the lime employed for this purpose. Hydrated clay unites with the ammonia of the gas as with a base, and, at the same time, with its sulphuret of carbon as an acid, and thus removes both of these noxious impurities from the gas exposed to its influence. It assists also, in conjunction with the lime, in removing tarry vapor and other impurities from the gas. The illuminating power of the gas is positively increased by the clay purification from 22 to 33⅓ per cent.

To Joint Lead Plates.—The joints of lead plates for some purposes are made as follows: The edges are brought together, hammered down into a sort of channel cut out of wood, and secured with a few tacks. The hollow is then scraped clean with a scraper, rubbed over with candle grease, and a stream of hot lead is poured into it, the surface being afterwards smoothed with a red hot plumber's iron.

To Joint Lead Pipes.—Widen out the end of one pipe with a taper wood drift, and scrape it clean inside; scrape the end of the other pipe outside a little tapered, and insert it in the former, then solder it with common lead solder as before described; or, if it requires to be strong, rub a little tallow over, and cover the joint with a ball of melted lead, holding a cloth (2 or 3 plies of greased bedtick) on the under side; and smoothing over with it and the plumber's iron.

Composition used in Welding Cast Steel.—Borax, 10; sal ammoniac, 1 part; grind or pound them roughly together; then fuse them in a metal pot over a clear fire, taking care to continue the heat until all spume has disappeared from the surface. When the liquid appears clear, the composition is ready to be poured out to cool and concrete; afterwards being ground to a fine powder it is ready for use. To use this composition, the steel to be welded is raised to a heat which may be expressed by "bright yellow;" it is then dipped among the welding powder, and again placed in the fire until it attains the same degree of heat as before; it is then ready to be placed under the hammer.

To prevent Deposits of Lime in Boilers.—Throw into the tank or reservoir from which your boiler is fed, a quantity of rough bark, in the piece, such as tanners use, sufficient to turn the water of a brown color; if you have no tank, put into the boiler from a half to a bushel of ground bark when you blow off; repeat every month, using only half the quantity after the first time.

Scaling Cast Iron.—Vitriol, 1 part; water, 2 parts; mix and lay on the diluted vitriol with some old cloth in the form of a brush, enough to wet the surface well; after 8 or 10 hours, wash off with water, when the hard, scaly surface will be completely removed.

Varnish, for Smooth Moulding Patterns.—Alcohol, 1 gallon; shellac, 1 lb.; lamp or ivory black, sufficient to color it.

Cast Iron Ornaments are rendered susceptible of being finished with a scraper, where they cannot be reached with files, after having the above liquid applied to them.

Iron Lustre is obtained by dissolving a piece of zinc with muriatic acid, and mixing the solution with spirit of tar, and applying it to the surface of iron.

To Melt Steel as Easily as Lead.—This apparent impossibility is easily performed by heating the bar of iron or steel red hot, and then touching it with a roll of brimstone, when the metal will drop like water.

Patent Lubricating Oil.—Water, 1 gal.; clean tallow, 3 lbs.; palm oil, 10 lbs.; common soda, ½ lb. Heat the mixture to about 210° F.; stir well till it cools down to 70° F., when it is fit for use.

Black Having a Polish for Iron.—Pulverized gum asphaltum, 2 lbs.; gum benzoin, ¼ lb.; spirits of turpentine, 1 gal.; to make quick, keep in a warm place, and shake often; shade to suit with finely ground ivory black. Apply with a brush. And it ought to be used on iron exposed to the weather as well as on inside work, desiring a nice appearance or polish. Or:

Varnish for Iron.—Asphaltum, 8 lbs.; melt in an iron kettle, slowly adding boiled linseed oil, 5 gals.; litharge, 1 lb., and sulphate of zinc, ½ lb.; continuing to boil for 3 hours; then add dark gum amber, 1½ lbs.; and continue to boil 2 hours longer. When cool, reduce to a proper consistence to apply with a brush, with spirits of turpentine.

To Restore Burnt Steel, and improve Poor Steel.—Borax, 3 oz.; sal ammoniac, 8 oz.; prussiate of potash, 3 oz.; blue clay, 2 oz.; resin, 1½ lbs.; water, 1 gill; alcohol, 1 gill. Put all on the fire, and simmer till it dries to a powder. The steel is to be heated, and dipped into this powder, and afterwards hammered.

Composition to toughen Steel.—Resin, 2 lbs.; tallow, 2 lbs.; black pitch, 1 lb.; melt together, and dip in the steel when hot.

Burglar and Drill Proof Diamond Chill.—Take 1 gal. urine, and add to it 1 oz. borax and 1 oz. salt.

How to Re-cut Old Files and Rasps.—Dissolve 4 oz. of saleratus in 1 qt. of water, and boil the files in it for half an hour; then remove, wash and dry them. Now have ready, in a glass or stone-ware vessel, 1 qt. of rain water, into which you have slowly added 4 oz. of best sulphuric acid, and keep the proportions for any amount used. Immerse the files in this preparation for from six to twelve hours, according to fineness or coarseness of the file; then remove; wash them clean, dry quickly, and put a little sweet oil on them to cover the surface. If the files are coarse, they will need to remain in about twelve hours, but for fine files six to eight hours is sufficient. This plan is applicable to blacksmiths', gunsmiths', tinners', coppersmiths', and machinists' files. Copper and tin workers will only require a short time to take the articles out of their files, as the soft metals with which they become filled are soon dissolved. Blacksmiths' and saw-mill files require full time. Files may be recut three times by this process. The liquid may be used at different times if required. Keep away from children, as it is poisonous.

Substitute for Borax.—Copperas, 2 oz.; saltpetre, 1 oz.; common salt, 6 oz.; black oxide of manganese, 1 oz.; prussiate of potash, 1 oz.; all pulverized and mixed with 3 lbs. nice welding sand, and use the same as you would sand. High-tempered steel can be welded with this at a lower heat than is required for borax.

Tempering Liquid.—To 6 qts. soft water put in corrosive sublimate, 1 oz.; common salt, 2 handfuls; when dissolved, it is ready for use. The first gives toughness to the steel, while the latter gives the hardness. Be careful with this preparation, as it is a dangerous poison.

Another.—Salt, ½ tea-cup; saltpetre, ½ oz., alum, pulverized, 1 teaspoon; soft water, 1 gallon; never heat over a cherry red, nor draw any temper.

Another.—Saltpetre, sal-ammoniac and alum, of each 2 oz.; salt, 1½ lbs.; water, 3 gallons, and draw no temper

Another.—Saltpetre and alum each, 2 oz.; sal-ammoniac, ½ oz.; salt, 1½ lbs.; soft water, 2 gallons. Heat to a cherry red, and plunge in, drawing no temper.

Another.—Water, 3 gallons; salt, 2 qts.; sal-ammoniac and saltpetre, of each 2 oz.; ashes from white-ash bark, 1 shovel, which causes the steel to scale white and smooth as silver. Do not hammer too cold, to avoid flaws; do not heat too high, which opens the pores of the steel; and do not heat more than one or two inches of the steel at a time while tempering, if you wish the hardness and toughness of the steel to be of the first quality.

To Improve Poor Iron.—Black oxide of manganese, 1 part; copperas and common salt, 4 parts each; dissolve in soft water, and boil till dry; when cool, pulverize and mix quite freely with nice welding sand. When you have poor iron which you cannot afford to throw away, heat it, and roll it in this mixture; working for a time, reheating, &c., will soon free it from all impurities, which is the cause of its rottenness. By this process you can make good horse-nails out of common iron.

Case Hardening for Iron.—Case iron may be case-hardened by heating to a red heat, and then rolling it in a composition composed of equal parts of prussiate of potash, sal-ammoniac, and saltpetre, all pulverized and thoroughly mixed. This must be got to every part of the surface; then plunged, while yet hot, into a bath containing 2 oz. prussiate of potash, and 4 oz. sal-ammoniac to each gallon of cold water.

For Malleable Iron.—Put the articles in an iron box, and stratify them among animal carbon, that is, pieces of horns, hoofs, skins or leather, just sufficiently burned to be reduced to powder. Lute the box with equal parts of sand and clay; then place it in the fire, and keep at a light red heat for a length of time proportioned to the depth of steel required, when the contents of the box are emptied into water.

Another for Wrought Iron.—Take the prussiate of potash, finely pulverized, and roll the article in it, if its shape admits of it; if not, sprinkle the powder upon it freely while the iron is hot.

To Soften Cast Iron for Drilling.—Heat to a cherry red, having it lie level in the fire; then with a pair of cold tongs put on a piece of brimstone, a little less in size than the hole to be when drilled, and it softens entirely through the piece; let it lie in the fire until a little cool, when it is ready for drilling.

To Temper Springs.—For tempering cast-steel trap springs, all that is necessary is to heat them in the *dark*, just so that you can see that they are red; then cool them in luke-warm water. You can observe a much lower degree of heat in the dark than by daylight, and the low heat and warm water give the desired temper.

To Mend Broken Saws.—Pure silver, 19 parts; pure copper, 1 part; pure brass, 2 parts; all to be filed into powder, and thoroughly mixed; place the saw level on the anvil, broken edges in contact, and hold them so; now put a small line of the mixture along the seam, covering it with a larger bulk of powdered charcoal; now with a spirit lamp and a jeweller's blow-pipe, hold the coal dust in place, and blow sufficient to melt the solder mixture; then with a hammer set the joint smooth, and file away any superfluous solder, and you will be surprised at its strength; the heat will not injure the temper of the saw.

Writing Inscriptions on Metals.—Take ½ lb. nitric acid and 1 oz. muriatic acid. Mix, shake well together, and it is ready for use. Cover the place you wish to mark with melted bees-wax; when cold, write your inscription plainly in the wax clear to the metal with a sharp instrument; then apply the mixed acids with a feather, carefully filling each letter. Let it remain from one to ten minutes, according to appearance desired; then throw on water, which stops the process, and remove the wax.

Black Varnish for Iron Work.—Asphaltum, 1 lb.; lampblack, ¼ lb.; resin, ½ lb.; spirits turpentine, 1 qt.; linseed oil, just sufficient to rub up the lampblack with before mixing it with the others. Apply with a camel's hair brush.

To Petrify Wood.—Gem salt, rock alum, white vinegar, chalk and peebles powder, of each an equal quantity. Mix well together. If, after the ebullition is over, you throw into this liquid any wood or porous substance, it will petrify it.

The Finest Bronze.—Put in a clean crucible 7 lbs. copper, melt, then add 3 lbs. zinc, afterwards 2 lbs. tin. In order to gild polished steel or polished iron, dip the article into an ethereal solution of gold, withdraw from the solution, and the ether flies off and leaves the gold deposited.

Soft Cement, for Steam Boilers, Steam Pipes, &c.—Red or white lead, in oil, 4; iron borings, 2 to 3 parts.

Hard Cement.—Iron borings and salt water, and a small quantity of sal ammoniac with fresh water.

Black Varnish, for Coal Buckets.—Asphaltum, 1 lb.; lampblack, ¼ lb.; resin, ½ lb.; spirits of turpentine, 1 qt. Dissolve the asphaltum and resin in the turpentine; then rub the lampblack with linseed oil, only sufficient to form a paste, and mix with the others. Apply with a brush.

Soldering Fluid.—Take 2 oz. muriatic acid; add zinc till bubbles cease to rise; add ½ teaspoonful of sal ammoniac and 2 oz. of water. Damp the part you wish to solder with this fluid; lay on a small piece of solder, and with a piece of hot iron or soldering iron solder the part.

Japan Flow for Tin.—ALL COLORS.—Gum sandarac, 1 lb.; balsam of fir, balsam of Tolu, and acetate of lead, of each, 2 oz.; linseed oil, ½ pint; spirits of turpentine, 2 qts. Put all into a suitable kettle, except the turpentine, over a slow fire, at first; then raise to a higher heat till all are metled; now take from the fire, and, when a little cool, stir in the spirits of turpentine, and strain through a fine cloth. This is transparent; but by the following modifications any or all the various colors are made from it.

2. BLACK.—Prussian blue, 1 oz.; asphaltum, 2 oz.; spirits of turpentine, ½ pint. Melt the asphaltum in the turpentine; rub up the blue with a little of it; mix well, and strain; then add the whole to 1 pint of the *first*, above.

3. BLUE.—Indigo, and Prussian blue, both finely pulverized, of each ½ oz.; spirits of turpentine, 1 pint. Mix well, and strain. Add of this to one pint of the *first* until the color suits.

4. RED.—Take spirits of turpentine, ½ pt.; add cochineal, ½ oz.; let stand 15 hours, and strain. Add of this to the *first* to suit the fancy. If carmine is used instead of cochineal, it will make a fine color for watch hands.

5. YELLOW.—Take 1 oz. of pulverized root of curcuma, and stir of it into 1 pt. of the *first* until the color pleases you; let stand a few hours, and strain.

6. GREEN.—Mix equal parts of the blue and yellow together, then mix with the *first* until it suits the fancy.

7. ORANGE.—Mix a little of the red with more of the yellow, and then with the *first* as heretofore, until pleased.

8. PINK.—Mix a little of the blue to more in quantity of the red, and then with the *first* until suited. Apply with a brush.

Transparent Blue for Iron or Steel.—Demar varnish, ½ gal.; fine ground Prussian blue, ½ oz.; mix thoroughly. Makes a splendid appearance. Excellent for blueing watch hands.

To Tin Copper Stew Dishes, etc.—Wash the surface of the article to be tinned with sulphuric acid, and rub the surface well, so as to have it smooth and free of blackness caused by the acid; then sprinkle calcined and finely pulverized sal-ammoniac upon the surface, holding it over a fire, when it will be sufficiently hot to melt a bar of solder which is to be rubbed over the surface: any copper dish or vessel may be tinned in this way.

To Copper the Surface of Iron, Steel, or Iron Wire.—Have the article perfectly clean, then wash with the following solution, and it presents at once a coppered surface. Rain water, 3 lbs.; sulphate of copper, 1 lb.

To Tin Iron for Soldering, &c.—Take any quantity of muriatic acid, and dissolve all the zinc in it that it will cut; dilute it with one-fourth as much soft water as of acid, and it is ready for use. Rub this liquid on iron; and no matter how rusty it may be, it will brighten it up so that solder will readily adhere to it; or the above copper solution may be applied, giving it a coat of copper.

Gold Lacquer for Tin.—TRANSPARENT, ALL COLORS.—Alcohol in a flask, ½ pt.; add gum shellac, 1 oz.; turmeric, ½ oz.; red sanders, ¼ oz. Set the flask in a warm place, shake frequently for 12 hours or more, then strain off the liquor, rinse the bottle, and return it, corking tightly for use.

When this varnish is used, it must be applied to the work freely and flowing; and the article must be hot when applied. One or more coats may be laid on, as the color is required more or less light or deep. If any of it should become thick from evaporation, at any time, thin it with alcohol. And by the following modifications, all the various colors are obtained.

2. ROSE COLOR.—Proceed as above, substituting ¼ oz. of finely ground best lake in place of the turmeric.

3. BLUE.—The blue is made by substituting pulverized Prussian blue, ½ oz., in place of the turmeric.

4. PURPLE.—Add a little of the blue to the *first.*

5. GREEN.—Add a little of the rose-color to the *first.*

Crystallized Tin Plate.—The figures are more or less beautiful and diversified, according to the degree of heat, and relative dilution of the acid. Place the tin-plate, slightly heated, over a tub of water, and rub its surface with a sponge dipped in a liquor composed of four parts of aquafortis, and two of distilled water, holding one part of common salt or sal ammoniac in solution. Whenever the crystalline spangles seem to be thoroughly brought out, the plate must be immersed in water, 'washed either with a feather or a little cotton (taking care not to rub off the film of tin that forms the feathering), forthwith dried with a low heat, and coated with a lacker varnish, otherwise it loses its lustre in the air. If the whole surface is not plunged at once in cold water, but if it be partially cooled by sprinkling water on it, the crystallization will be finely variegated with large and small figures. Similar results will be obtained by blowing cold air through a pipe on the tinned surface, while it is just passing from the fused to the solid state.

To Crystallize Tin.—Sulphuric acid, 4 oz.; soft water, 2 to 3 oz., according to strength of the acid; salt, 1¼ oz; mix; heat the tin hot over a stove, then with a sponge apply the mixture, then wash off directly with clean water. Dry the tin, and varnish with demar varnish.

Improved Tinning Flux.—Muriatic acid, 1 lb.; put into it all the zinc it will dissolve and 1 oz. sal ammoniac, and it is ready for use.

To Clean and Polish Brass.—Oil of vitriol, 1 oz.; sweet oil, ½ gill; pulverized rotten stone, 1 gill; rain water, 1½ pints; mix all, and shake as used. Apply with a rag, and polish with buckskin or old woolen.

Silvering Powder.—Nitrate of silver and common salt, of each, 30 grs; cream of tartar, 3½ drs. Pulverize finely, mix thoroughly, and bottle for use. Unequalled for polishing copper and plated goods.

Tin Cans.—SIZE OF SHEET, FOR FROM 1 TO 100 GALLONS:

For 1 gallon,	7 by 20 inches.	For 25 gallons,	30 by 56 inches.
3½ "	10 by 28 "	40 "	36 by 63 "
5 "	12 by 40 "	50 "	40 by 70 "
6 "	14 by 40 "	75 "	40 by 84 "
10 "	20 by 42 "	100 "	40 by 98 "
15 "	30 by 42 "		

This includes all the laps, seams, &c., which will be found sufficiently correct for all practical purposes.

To Mend Tinware.—Take a vial two-thirds full of muriatic acid, put into it all the chippings of sheet zinc it will dissolve, then put in a crumb of sal ammoniac, and fill up with water. Wet the place to be mended with this liquid, put a piece of zinc over the hole, and apply a spirit lamp or candle below it, which melts the solder on the tin and causes the zinc to adhere.

Brunswick Black for Grates, &c.—Asphaltum, 5 lbs.; melt, and add boiled oil, 2 lbs.; spirits of turpentine, 1 gal. Mix.

Gas Fitter's Cement.—Mix together rosin, four and a half parts; wax, 1 part; and Venetian red, 3 parts.

Plumber's Cement.—Black resin, 1 part; brick dust, 2 parts; well incorporated by a melting heat. Boiled linseed oil and red lead mixed together into a putty are often used by coppersmiths and engineers to secure joints; the washers of leather or cloth are smeared with this mixture in a pasty state.

Browning for Gun Barrels.—Spirits of nitre, 1 lb.; alcohol, 1 lb.; corrosive sublimate, 1 oz.; mix in a bottle, and cork for use. Directions: Polish the barrel perfect; then rub it with quick-lime with a cloth, which removes grease and dirt; now apply the browning fluid with a clean white cloth; apply one coat, and set it in a warm dark place for from 10 to 20 hours until a red rust forms on it; then cord it down with a gunmaker's cord, and rub off with a clean cloth. Repeat the process if you wish a dark shade.

Browning for Twist Barrels.—Spirits of nitre, ¾ oz.; tincture of steel, ¾ oz.; or use the unmedicated tincture of iron if the tincture of steel cannot be obtained; black brimstone, ¼ oz.; blue vitriol, ½ oz.; corrosive sublimate, ¼ oz.; nitric acid, 1 drachm; copperas, ¼ oz.; mix with 1½ pints rain water, and bottle for use. This is to be applied the same as the first. It causes the twist of the barrel to be visible after application, a quality which the other liquid does not possess.

Browning Compositions for Gun Barrels.—1. Blue vitriol, 4 oz.; tincture of muriate of iron, 2 oz.; water, 1 quart; dissolve, and add aquafortis and sweet spirits of nitre, of each, 1 oz. 2. Blue vitriol and sweet spirits of nitre, of each, 1 oz.; aquafortis, ½ oz.; water, 1 pint. To be used in the same manner as previously described in this work.

Varnish and Polish for Gun Stocks.—Gum shellac, 10 oz.; gum sandarac, 1 oz.; Venice turpentine, 1 drachm; 98 per cent. alcohol, 1 gallon; shake the jug occasionally for a day or two, and it is ready for use. Apply a few coats of this to your gunstocks, polish by rubbing smooth, and your work is complete.

Hardening and Filling for Fire-proof Safes.—Experience has shown that the fire and burglar proof diamond chill for iron or steel, described in another part of this work, has no superior as a hardening for security in the construction of safes; and, as a non-conductor of heat, we would recommend a filling of plaster of Paris or alum.

Tempering Razors, Cutlery, Saws, &c.—Razors and penknives are too frequently hardened without the removal of the scale arising from the forging. *This practice, which is never done with the best works, cannot be too much deprecated.* The blades are heated in a coke or charcoal fire, and dipped in the water obliquely. In tempering razors, they are laid on their backs upon a clean fire, about half a dozen together, and they are removed one at a time, when the edges, which are as yet thick, come down to a pale straw color. Should the backs accidentally get heated beyond the straw-color, the blades are cooled in water, but not otherwise. Penblades are tempered a dozen or two at a time, on a plate of iron or copper, about 12 inches long, 3 or 4 inches wide, and about ¼ of an inch thick. The blades are arranged close together on their backs, and lean at an angle against each other. As they come down to the temper, they are picked out with small pliers and thrown into water, if necessary; other blades are then thrust forward from the cooler parts of the plate to take their place. Axes, adzes, cold chisels, and other edge tools, in which the total bulk is considerable compared with the part to be hardened, are only partially dipped; they are afterwards let down by the heat of the remainder of the tool; and, when the color indicative of the temper is attained, they are entirely quenched. With the view of removing the loose scales, or the oxidation acquired in the fire, some workmen rub the objects hastily in dry salt before plunging them in the water, in order to give them a cleaner and brighter face.

Oil, or resinous mixtures of oil, tallow, wax, and resin, are used for many thin and elastic objects, such as needles, fishhooks, steel-pens and springs, which require a milder degree of hardness than is given by water. Gunlock springs are sometimes *fried in oil* for a considerable time over a fire, in an iron tray; the thick parts are then sure to be sufficiently reduced, and the thin parts do not become the more softened from the continuance of the blazing heat.

Saws and springs are generally hardened in various compositions of oil, suet, wax, etc. The saws are heated in long furnaces, and then immersed horizontally and edgeways into a long trough containing the composition. Part of the composition is wiped off the saws with a piece of leather, when they are removed from the trough, and heated one by one, until the grease inflames. This is called "*blazing off*." The composition used by a large saw manufacturer is 2 lbs. suet, and ¼ lb. of beeswax, to every gallon of whale oil; these are boiled together, and will serve for thin works and most kinds of steel. The addition of black resin, about 1 lb. to each gallon, makes it serve for thicker pieces, and for those it refused to harden before; but resin should be added with judgment, or the works will become too hard and brittle.

Silversmith's Stripping Liquid.—Sulphuric acid, 8 parts; nitre, 1 part. Use to re-cover silver on old plated ware.

To Silver Clock Faces, Etc.—Old silver lace, ½ oz.; nitric acid, 1 oz. Boil them over a gentle fire for about 5 minutes in an earthen pot. After the silver is dissolved, take the mixture off, and mix it in a pint of clean water, then pour it into another vessel, free from sediment; then add a tablespoonful of common salt, and the silver will be precipitated in the form of a white powder or curd; pour off the acid, and mix the curd with 2 oz. salt of tartar, and ½ oz. whiting, all together, and it is ready for use. TO USE.—Clean your brass or copper plate with rotten stone and a piece of old hat; rub it with salt and water with your hand. Then take a little of the composition on your finger, and rub it over your plate, and it will firmly adhere and completly silver it. Wash it well with water. When dry, rub it with a clean rag, and varnish with this VARNISH FOR CLOCK-FACES: Spirits of wine, 1 pt.; divide into 3 parts, mix one part with gum mastic in a bottle by itself; 1 part spirits, and ½ oz. sandarac in another bottle; and 1 part spirits, and ½ oz. of whitest gum benjamin, in another bottle; mix and temper to your mind. If too thin, some mastic; if too soft, some sandarac or benjamin. When you use it, warm the silvered plate before the fire, and, with a flat camel's hair pencil, stroke it over till no white streaks appear, and this will preserve the silvering for many years.

Watchmaker's Drills.—Drills of the smallest kind are heated in the blue part of the flame of a candle; larger drills are heated with the blow-pipe flame, applied very obliquely, and a little below the point. When very thin, they may be whisked in the air to cool them; but they are generally thrust into the tallow of a candle or the oil of a lamp. They are tempered either by their own heat, or by immersion in the flame below the point of the tool.

To Reduce Metallic Oxides.—This may be effected by the dry and the moist processes; but the deoxidizing agent of the greatest value to the metallurgist is coal in its several varieties, and the derivative materials yielded by its combustion. When coal is burned in a furnace, the first product of combustion may be considered to be carbonic acid gas; but inasmuch as the latter is readily decomposed by permeating ignited pieces of solid carbon (coke) losing a portion of its oxygen, and becoming carbonic acid gas, we may say that the products of the combustion of coal are, firstly, carbonic acid; secondly, carbonic oxide and carbonic acid; and lastly, carbonic oxide alone. The latter, in combination with heat, is a most powerful deoxidizing agent. Were it not for the production in furnaces of carbonic oxide gas—were it necessary that the solid carbon of the coke should be alone the deoxidizing body—then it follows that every particle of the ore to be reduced must be brought into intimate contact with the reducing body; a process involving more care and trouble than are compatible with large metallurgic operations. The reducing agent being a gas, there is no longer a necessity for that intimate mixture of fuel and ore which would otherwise be necessary. Provided that the gaseous results of combustion are placed under circumstances of readily permeating the ore, the necessities of practice are amply subserved. There is great difference as to the amount of heat at which the reduction of different metallic oxides can be effected. The oxides of lead, bismuth, antimony, nickel, cobalt, copper, and iron, require a strong red heat in the furnace, whilst the oxides of manganese, chromium, tin, and zinc, do not lose their oxygen until heated to whiteness.

On a large scale, the reduction of oxides is generally effected by mixing charcoal, together with the oxide to be reduced, in a refractory clay crucible, the charcoal furnishing the carbon necessary to the proper performance of the work. Some use a crucible thickly lined with charcoal, putting in the oxide on the top of the charcoal. It is necessary, however, when using the crucible and charcoal, to use a flux, say a little borax in powder, stewed on the mixture to accelerate the reduction of the oxide. The borax is generally the first to fuse, and, as the metal is eliminated, seems to purify and cleanse it, as it gathers into a button at the bottom of the crucible. It is all the better if you give the crucible a few sharp taps when you take it off the fire.

Copper Plates or Rods may be covered with a superficial coating of brass by exposing them to the *fumes* given off by melted zinc at a light temperature. The coated plates or rods can then be rolled into thin sheets; or drawn into wire.

Solution of Copper on Zinc.—Dissolve 8 oz. (troy) cyanide of potassium, and 3 oz. cyanide of copper or zinc, in 1 gallon of rainwater. To be used at about 160° F., with a compound battery of 3 to 12 cells.

Brass Solution.—Dissolve 1 lb. (troy) cyanide of potassium, 2 ozs. cyanide of copper, and 1 oz. cyanide of zinc, in 1 gal. of rain-water; then add 2 oz. of muriate ammonia. To be used at 160° F., for smooth work, with a compound battery of from 3 to 12 cells.

Brassing Iron.—Iron ornaments are covered with copper or brass, by properly preparing the surface so as to remove all organic matter which would prevent adhesion and then plunging them into melted brass. A thin coating is thus spread over the iron, and it admits of being polished or burnished.

To Enamel Cast Iron and Hollow Ware.—Calcined flints 6 parts; Cornish stone or *composition* two parts, litharge 9 parts, borax 6 parts, argillaceous earth 1 part, nitre 1 part, calx of tin 6 parts, purified potash 1 part. 2. Calcined flints 8 parts, red lead 8 parts, borax 6 parts, calx of tin 5 parts, nitre 1 part. 3. Potter's composition 12 parts, borax 8 parts, white lead 10 parts, nitre 2 parts, white marble calcined 1 part, purified potash 2 parts, calx of tin 5 parts. 4. Calcined flints 4 parts, potter's composition 1 part, nitre 2 parts, borax 8 parts, white marble calcined 1 part, argillaceous earth ½ part, calx of tin 2 parts. Whichever of the above compositions is taken must be finely powdered, mixed and fused. The vitreous mass is to be ground when cold, sifted, and levigated with water; it is then made into a pap with water, or gum-water. This pap is smeared or brushed over the interior of the vessel, dried, and fused with a proper heat in a muffle. Clean the vessels perfectly before applying.

Enameled Cast Iron.—Clean and brighten the iron before applying. The enamel consists of two coats—the body and the glaze. The body is made by fusing 100 lbs. ground flints, 75 of borax, and grinding 40 lbs. of this frit with 5 lbs. of potter's clay, in water, till it is brought to the consistence of a pap. A coat of this being applied and dried, but not hard, the glaze powder is sifted over it. This consists of 100 lbs. Cornish stone in fine powder, 117 of borax, 35 of soda ash, 35 of nitre, 35 of sifted slaked lime, 13 of white sand, and 50 of pounded white glass. These are all fused together; the frit obtained is pulverized. Of this powder, 45 lbs. are mixed with 1 lb. of soda ash, in hot water, and the mixture dried in a stove is the glaze-powder. After sifting this over the body-coat, the cast iron article is put into a stove, kept at a temperature of about 212°, to dry it hard, after which it is set in a muffle-kiln, to fuse it into a glaze. The inside of pipes is enamelled (after being cleaned) by pouring the above body-composition through them while the pipe is being turned around to insure an equal coating; after the body has become set, the glaze pap is poured in in like manner. The pipe is finally fired in the kiln.

To Enamel Copper and other Vessels.—Flint glass 6 parts, borax 3 parts, red lead 1 part, oxide of tin 1 part. Mix all together, frit, grind into powder, make into a thin paste with water, apply with a brush to the surface of the vessels (after sealing by heat and cleaning them), repeat with a second or even a third coat, afterwards dry, and lastly fuse on by heat of an enamelled kiln.

Emery Wheels for Polishing.—Coarse emery powder is mixed with about half its weight of pulverized Stourbridge loam, and a little water or other liquid to make a thick paste; this is pressed into a metallic mould by means of a screw-press, and, after being thoroughly dried, is baked or burned in a muffle at a temperature above a red, and below a white heat. This forms an artificial emery-stone, which cuts very greedily, with very little wear to itself. Unequalled for grinding and polishing glass, metals, enamels, stones, &c.

Refining Gold and Silver.—The art of assaying gold and silver is founded upon the feeble affinity which these have for oxygen in comparison with copper, tin, and other cheap metals, and on the tendency which the latter metals have to oxidize rapidly in contact with lead at a high temperature, and sink with it into any porous, earthy vessel in a thin, glassy, vitrified mass. The precious metal having previously been accurately weighed and prepared, the first process is CUPELLATION. The *muffle*, with cupel properly arranged on the "*muffle plate*," is placed in the furnace, and the charcoal added, and lighted at the top by means of a few ignited pieces thrown on last. After the cupels have been exposed to a strong white heat for about half an hour, and have become white hot, the lead is put into them by means of tongs. As soon as this becomes bright red and "*circulating*," as it is called, the specimen for assay, wrapped in a small piece of paper or lead-foil, is added; the fire is now kept up strongly until the metal enters the lead and "*circulates*" well, when the heat, slightly diminished, is so regulated that the assay appears convex and more glowing than the cupel itself, whilst the "*undulations*" circulate in all directions, and the middle of the metal appears smooth, with a margin of litharge, which is freely absorbed by the cupel. When the metal becomes bright and shining, or, in the technical language, begins to "*lighten*," and prismatic hues suddenly flash across the globules, and undulate and cross each other, followed by the metal becoming very brilliant and clear, and at length bright and solid (called *the brightening*), the separation is ended, and the process complete. The cupels are then drawn to the mouth of the "muffle," and allowed to cool slowly. When quite cold, the resulting "*button*," if of SILVER, is removed by the "pliers" or "tongs" from the cupels, and after being flattened on a small *anvil of polished steel*, with a polished steel hammer, to detach adhering oxide of lead, and cleaned with a small, hard brush, is very *accurately weighed*. The weight is that of *pure silver*, and the difference between the weight before cupellation and that of the pure metal represents the proportion of alloy in the sample examined. In the case of GOLD, the metal has next to undergo the operations of QUARTATION. The cupelled sample is fused with three times its weight of pure silver (called the "*witness*,") and in this state may be easily removed by PARTING. The alloy, after quartation, is hammered or rolled out into a thin strip or leaf, curled into a spiral form, and boiled for a quarter of an hour with about 2½ to 3 ounces of nitric acid (specific gravity, 1.3); and the fluid being poured off, it is again boiled in a similar manner, with 1½ to 2 ounces more nitric acid (sp. gr., 1.2); after which the gold is carefully collected, washed in pure water, and dried. When the operation of parting is skilfully conducted, the acid not too strong, the metal preserves its spiral form; otherwise it falls into flakes or powder. The second boiling is termed the "*reprise*." The loss of weight by parting corresponds to the quantity of SILVER originally in the specimen.

For Alloys containing Platinum, which usually consist of copper, silver, platinum, and gold, the method of assaying is as follows: The alloy is cupelled in the usual way, the loss of weight expresses the amount of *copper*, and the "button," made into a riband and treated with sulphuric acid, indicates by the portion dissolved that also of the *silver* present. By submitting the residuum to quartation, the *platinum* becomes soluble in nitric acid. The loss after digestion in this menstruum expresses the weight of that metal, and the weight of the portion now remaining is that of pure gold. Gold containing PALLADIUM may be assayed in the same manner.

Annealing.—This consists in putting the pure gold into a small, porous crucible, or cupel, and heating it to redness in the muffle. WEIGHING must be done with the utmost accuracy. The weight in grains troy, doubled or quadrupled as the case may be, gives the number of *carats fine* of the alloy examined, without calculation.

According to the OLD FRENCH METHOD of assaying gold, the following quantities were taken: For the *assay pound*, 12 gr.; fine silver, 30 grs.; lead, 108 grs. These having been cupelled together, the perfect button is rolled into a leaf (1¼ by 5 inches), twisted on a quill, and submitted to parting with 2½ oz. and 1½. oz. of nitric acid, sp. gr., 1.16 (20° Baume). The remainder of the process is similar to that above described.

The usual weight of silver taken for the *assay pound*, when the fineness is reckoned in 1000ths, is 20 grs., every real grain of which represents 50-1000ths of fineness, and so on of smaller divisions.

Enamelling on Gold and Copper.—The basis of all enamels is a highly transparent and fusible glass, called FRIT, FLUX, or PASTE, which readily receives a color on the addition of the metallic oxides. PREPARATION.—Red lead, 16 parts; calcined borax, 3 parts; pounded flint glass, 12 parts; flints, 4 parts. Fuse in a Hessian crucible for 12 hours, then pour it out into water, and reduce it to powder in a biscuit-ware mortar. The following directions will serve to show how the coloring preparations are made: BLACK enamels are made with peroxide of manganese, or protoxide of iron, to which more depth of color is given with a little cobalt. VIOLET enamel of a very fine hue is made from peroxyde of manganese in small quantity with saline or alkaline fluxes. RED enamel is made from protoxide of copper. Boil a solution of equal parts of sugar and acetate of copper in four parts of water. The sugar takes possession of a portion of the cupreous oxide, and reduces it to the protoxide; when it may be precipitated in the form of a granular powder of a brilliant red. After about two hours of moderate boiling, the liquid is set aside to settle, decanted off the precipitate, which is washed and dried. By this pure oxide any tint may be obtained from red to orange by adding a greater or smaller quantity of peroxide of iron. The oxide and purple of cassius are likewise employed to colored enamel. This composition resists a strong fire very well. GREEN enamel can be produced by a mixture of yellow and blue, but is generally obtained direct from the oxide of copper, or better still with the oxide of chrome, which last will resist a strong heat. YELLOW.—Take one part of white oxide of antimony, with from one to three parts of white lead, one of alum, and one of sal ammoniac. Each of these substances is to be pulverized, then all are to be exactly mixed, and exposed to a heat adequate to decompose the sal ammoniac. This operation is judged to be finished when the yellow color is well brought out. BLUE.—This color is obtained from the oxide of cobalt, or some of its combinations, and it produces it with such intensity that only a very little can be used lest the shade should pass into black. A WHITE enamel may be prepared with a *calcine* formed of 2 parts of tin and 1 of lead, calcined together: of this combined oxide, 1 part is melted with two parts of fine crystal and a very little manganese, all previously ground together. When the fusion is complete, the vitreous matter is to be poured into clear water, and the frit is then dried and melted anew. Repeat the pouring into water three or four times, to insure a perfect combination. Screen the crucible from smoke and flame. The smallest portions of oxide of iron or copper admitted into this enamel will destroy its value.

The artist prepares his enamel colors by pounding them in an agate mortar, with an agate pestle, and grinding them on an agate slab, with oil of lavender rendered viscid by exposure to the sun, in a shallow vessel, loosely covered with gauze or glass. He should have alongside of him a stove, in which a moderate fire is kept up, for drying his work whenever the figures are finished. It is then passed through the muffle.

Silver Plating.—File the parts which are to receive the plate very smooth; then apply over the surface the muriate of zinc, which is made by dissolving zinc in muriatic acid; now hold this part over a dish containing hot soft solder, and with a swab apply the solder to the part to which it will adhere; brush off all superfluous solder, so as to leave the surface smooth; you will now take No. 2 fair silver plate, of the right size to cover the prepared surface, and lay the plate upon it, and rub down smooth with a cloth moistened with oil; then, with a turned soldering iron, pass slowly over all the surface of the plate, which melts the solder underneath it, causing the plate to adhere as firmly as the solder does to the iron; then polish the surface, and finish with buckskin.

Electro Gold Plating.—Take a $2.50 piece of gold, and put it into a mixture of 1 oz. nitric, and 4 oz. muriatic acid (glass vessels only are to be used in this work;) when it is all cut, dissolve ½ oz. of sulphate of potash in 1 pint of pure rain water, and mix with the gold solution, stirring well; then let it stand, and the gold will be thrown down; then pour off the acid fluid, and wash the gold in two or three waters, or until no acid is tasted by touching the tongue to the gold. Now dissolve 1 oz. of cyanuret of potassium in 1 pint of pure rain water, to which add the gold, and it is ready for use. Clean the article to be plated from all grease and dirt, with whiting and a good brush; if there are cracks, it may be necessary to put the article in a solution of caustic potash; at all events clean it perfectly; then suspend it in the cyanuret of gold solution with a small strip of zinc, cut about the width of a common knitting needle, hooking the top over a stick which will reach across the top of the vessel holding the solution. If the zinc is too large, the deposit will be made so fast it will scale off. The slower the plating goes on the better, and this is arranged by the size of the zinc used. When not in use keep it well corked and out of the way of children, for it is very poisonous.

Electro Silver Plating is done every way the same as gold (using coin,) except that rock-salt is used instead of the cyanuret of potassium, to hold the silver in solution for use, and when it is of the proper strength of salt, it has a thick curdy appearance, or you can add salt until the silver will deposit on the article to be plated, which is all that is required. This method entails no trouble with using a battery, and is the successful result of a long series of experiments in electro-plating.

Elkington's Patent Gilding.—Fine gold, 5 oz. (troy;) nitro-muriatic acid, 52 oz. (avoirdupois;) dissolve by heat, and continue the heat until red or yellow vapors cease to be evolved; decant the clear liquor into a suitable vessel; add *distilled* water, 4 gallons; pure bi-carbonate of potassa, 20 lbs.; and boil for 2 hours. N. B. The nitro-muriatic acid is made with *pure* nitric acid (sp. gr. 1.45,) 21 oz.; *pure* muriatic acid (sp. gr. 1.15,) 17 oz.; and *distilled* water, 14 oz.

The articles, after being perfectly cleaned from scale or grease, and receiving a proper *face*, are to be suspended on wires, dipped into the liquid *boiling hot*, and moved about therein, when, in from a few seconds to a minute, depending on the newness and strength of the liquid, the requisite coating of gold will be deposited on them. By a little practice the time to withdraw the articles is readily known; the duration of the immersion required to produce any given effect gradually increases as the liquid weakens by use. When properly gilded, the articles are withdrawn from the solution of gold, washed in clean water and dried; after which they undergo the usual operation of coloring, &c.

A "*dead gold" appearance* is produced by the application to the articles of a *weak* solution of *nitrate of mercury* previously to the immersion in the gilding liquor, or the *deadening* may be given by applying a solution of the nitrate to the *newly gilded* surface, and then expelling the mercury by heat.

Gold Silvering on Metals.—Mix 1 part of chloride of silver with 3 parts of pearlash, 1½ parts common salt, and 1 part whiting; and well rub the mixture on the surface of brass or copper, (previously well cleaned,) by means of a piece of soft leather, or a cork moistened with water, and dipped in the powder. When properly silvered, the metal should be well washed in hot water, slightly alkalized, then wiped dry.

To Heighten the Color of Yellow Gold.—Saltpetre, 6 oz.; green copperas, 2 oz.; white vitriol and alum, of each, 1 oz. If wanted redder, a small quantity of blue vitriol must be added.

For Green Gold.—Saltpetre, 1 oz. 10 dwts.; sal ammoniac, 1 oz. 4 dwts.; Roman vitriol, 1 oz. 4 dwts.; verdigris, 18 dwts.

For Red Gold.—To 4 oz. melted yellow wax, add, in fine powder, 1½ oz. of red ochre; 1½ oz. verdigris, calcined till it yields no fumes; and ½ oz. of calcined borax. Mix them well together. Dissolve either of above mixtures in water, as the color is wanted, and use as required.

Coloring of Gilding.—Defective colored gilding may also be improved by the help of the following mixture: Nitrate of potash, 3 oz.; alum, 1½ oz.; sulphate of zinc, 1½ oz.; common salt, 1½ oz. These ingredients are to be put into a small quantity of water to form a sort of paste, which is put upon the articles to be colored; they are then placed upon an iron plate over a clear fire, so that they will attain nearly to a black heat, when they are suddenly plunged into cold water; this gives them a beautiful high color. Different hues may be had by a variation in the mixture.

Gold is taken from the surface of silver by spreading over it a paste made of powdered sal-ammoniac, with aqua fortis, and heating it till the matter smokes, and it is nearly dry; when the gold may be separated by rubbing it with a scratch brush.

Moulds and Dies.—Copper, zinc, and silver in equal proportions, melt together under a coat of powdered charcoal, and mould into the form you desire. Bring them to nearly a white heat, and lay on the thing you would take the impression of, press with sufficient force, and you will get a perfect and beautiful impression.

Polishing Powder for Gold and Silver.—Rock alum (burnt and finely powdered,) 5 parts; levigated chalk, 1 part. Mix; apply with a dry brush.

Silver Plating Fluid.—Dissolve 1 ounce of nitrate of silver in crystal, in 12 ounces of soft water; then dissolve in the water 2 oz. cyanuret of potash; shake the whole together, and let it stand till it becomes clear. Have ready some half-ounce vials, and fill half full of Paris white, or fine whiting; and then fill up the bottles with the liquor, and it is ready for use. The whiting does not increase the coating power; it only helps to clean the articles, and save the silver fluid, by half filling the bottles.

To Temper Gravers and Drills.—When the graver or drill is too hard, which may be known by the frequent breaking of the point, temper as follows: Heat a poker red hot, and hold the graver to it within an inch of the point, waving it to and fro till the steel changes to a light straw color; then put the point into oil to cool, or hold the graver close to the flame of a candle till it be of the same color, and cool in tallow; but be careful either way not to hold it too long, for then it will be too soft, in which case the point will be blue, and must be broken off, and whetted and tempered anew. For jewellers' drills, no better tempering liquid can be got than the first-named liquid under the blacksmiths' department, which see.

Jeweler's Armenian Cement.—Isinglass soaked in water and dissolved in spirit, 2 oz. (thick); dissolve in this 10 grains of very pale gum ammonia (in tears) by rubbing them together; then add 6 large tears of gum mastic, dissolved in the least possible quantity of rectified spirit. When carefully made, this cement resists moisture and dries colorless. Keep in a closely stopped vial.

Jeweler's Turkish Cement.—Put into a bottle 2 oz. of isinglass and 1 oz. of the best gum arabic; cover them with proof spirits, cork loosely, and place the bottle in a vessel of water, and boil it till a thorough solution is effected; then strain for use; best cement known.

Reviver of Old Jewelry.—Dissolve sal-ammoniac in urine, and put the jewelry in it for a short time; then take it out, and rub with chamois leather, and it will appear equal to new.

To Recover Gold From Gilt Metal.—Take a solution of borax water, apply to the gilt surface, and sprinkle over it some finely powdered sulphur; make the article red hot, and quench it in water; then scrape off the gold, and recover it by means of lead.

To Separate Gold and Silver from Lace, &c.—Cut in pieces the gold or silver lace, tie it tightly, and boil it in soap lye till the size appears diminished; take the cloth out of the liquid, and, after repeated rinsings in cold water, beat it with a mallet to draw out all the alkali. Open the linen, and the pure metal will be found in all its beauty.

Door Plates—TO MAKE.--Cut your glass the right size, and make it perfectly clean with alcohol or soap; then cut a strip of tinfoil sufficiently long and wide for the name, and with a piece of ivory or other burnisher rub it lengthwise to make it smooth; now wet the glass with the tongue (as saliva is the best sticking substance,) or if the glass is very large, use a weak solution of gum arabic, or the white of an egg in half a pint of water, and lay on the foil, rubbing it down to the glass with a bit of cloth, then also with the burnisher; the more it is burnished the better will it look; now mark the width on the foil which is to be the height of the letter, and put on a straight edge, and hold it firmly to the foil, and with a sharp knife cut the foil, and take off the superfluous edges; then either lay out the letters on the back of the foil (so they shall read correctly on the front) by your own judgment or by means of pattern letters, which can be purchased for that purpose; cut with the knife, carefully holding down the pattern or straight edge, whichever you use; then rub down the edge of all the letters with the back of the knife, or edge of the burnisher, which prevents the black paint or japan which you next put over the back of the plate from getting under the foil; having put a line above and one below the name, or a border around the whole plate or not as you bargain for the job. The Japan is made by dissolving asphaltum in just enough turpentine to cut it (see "Asphaltum Varnish;") apply with a brush, as other paint, over the back of the letters, and over the glass forming a back ground. This is used on the iron plate of the frame, also putting it on when the plate is a little hot; and, as soon as it cools, it is dry. A little lamp-black may be rubbed into it if you desire it any blacker than it is without it.

Etching on Glass.—Druggist bottles, bar-tumblers, signs, and glassware of every description, can be lettered in a beautiful style of art, by simply giving the article to be engraved, or etched, a thin coat of the engraver's varnish (see next receipt), and the application of fluoric acid. Before doing so, the glass must be thoroughly cleaned and heated, so that it can hardly be held. The varnish is then to be applied lightly over, and made smooth by dabbing it with a small ball of silk, filled with cotton. When dry and even, the lines may be traced on it by a sharp steel, cutting clear through the varnish to the glass. The varnish must be removed clean from each letter, otherwise it will be an imperfect job. When all is ready, pour on or apply the fluoric acid with a feather, filling each letter. Let it remain until it etches to the required depth, then wash off with water, and remove the varnish.

Etching Varnish.—Take of virgin wax and asphaltum each 2 oz.; of black pitch and Burgundy pitch, each ½ oz.; melt the wax and pitch in a new earthenware glazed pot, and add to them, by degrees, the asphaltum, finely powdered. Let the whole boil, simmering gradually, till such time as that, taking a drop upon a plate, it will break when it is cold, on bending it double two or three times betwixt the fingers. The varnish, being then boiled enough, must be taken off the fire, and, after it cools a little, must be poured into warm water that it may work the more easily with the hands, so as to be formed into balls, which must be kneaded, and put into a piece of taffety for use.

Fluoric Acid, to Make for Etching Purposes.—You can make your own fluoric (sometimes called hydro-fluoric) acid, by getting the fluor or Derbyshire spar, pulverizing it, and putting all of it into sulphuric acid which the acid will cut or dissolve. Inasmuch as fluoric acid is destructive to glass, it cannot be kept in common bottles, but must be kept in lead or gutta percha bottles.

Glass-Grinding for Signs, Shades, Etc.—After you have etched a name or other design upon uncolored glass, and wish to have it show off to a better advantage by permitting the light to pass only through the letters, you can do so by taking a piece of flat brass sufficiently large not to dip into the letters, but pass over them when gliding upon the surface of the glass; then, with flour of emery, and keeping it wet, you can grind the whole surface, very quickly, to look like the ground glass globes often seen upon lamps, except the letter, which is eaten below the general surface.

Gold and Silver Ink.—The metal leaf is ground with honey until of a fine powder; it is then washed to remove the honey, and the powder is mixed with gum water for use.

Gold Lustre for Stoneware, China, Etc.—Gold, 6 parts; aquaregia, 36 parts. Dissolve, then add tin, 1 part; next add balsam of sulphur, 3 parts; oil of turpentine, 1 part. Mix gradually into a mortar, and rub it until the mixture becomes hard; then add oil of turpentine, 4 parts. It is then to be applied to a ground prepared for the purpose.

Gilding China and Glass.—Powdered gold is mixed with borax and gum water, and the solution applied with a camel-hair pencil. Heat is then applied by a stove until the borax fuses, when the gold is fixed and afterwards burnished.

Glass Staining.—The following colors, after having been prepared, and rubbed upon a plate of ground-glass, with the spirit of turpentine or lavender, thickened in the air, are applied with a hair-pencil. Before using them, however, it is necessary to try them on small pieces of glass, and expose them to the fire, to ascertain if the desired tone of color is produced. The artist must be guided by these proof-pieces in using his colors. The glass proper for receiving these pigments should be colorless, uniform and difficult of fusion. A design must be drawn on paper, and placed beneath the plate of glass. The upper side of the glass, being sponged over with gum-water, affords, when dry, a surface proper for receiving the colors without the risk of their running irregularly, as they would otherwise do on the slippery glass. The artist draws on the plate (usually in black), with a fine pencil, all the traces which mark the great outlines or shades of the figures. Afterwards, when it is dry, the vitrifying colors are laid on by means of larger hair-pencils; their selection being regulated by the burnt specimen-tints above mentioned. The following are all fast colors, which do not run, except the yellow, which must, therefore, be laid on the opposite side of the glass. The preparations being all laid on, the glass is ready for being fired in a muffle, in order to fix and bring out the proper colors. The muffle must be made of very refractory fire-clay, flat at its bottom, and only five or six inches high, with a strong, arched roof, and close on all sides, to exclude smoke and flame. On the bottom, a smooth bed of sifted lime, freed from water, about half an inch thick, must be prepared for receiving the glass. Sometimes, several plates of glass are laid over each other, with a layer of lime-powder between each. The fire is now lighted, and very gradually raised, lest the glass should be broken; then keep it at a full heat for three or four hours, more or less, according to the indications of the trial slips; the yellow coloring being principally watched, it furnishing the best criterion of the state of the others. When all is right, let the fire die out, so as to anneal the glass.

Stained-Glass Pigments.—No. 1. *Flesh color.*—Red lead, 1 oz.; red enamel (Venetian glass enamel, from alum and copperas calcined together): grind them to a fine powder, and work this up with alcohol upon a hard stone. When slightly baked, this produces a fine flesh color.

No. 2. BLACK COLOR.—Take 14½ oz. of smithy scales of iron; mix them with 2 oz. of white glass; antimony 1 oz.; manganese, ½ oz.: pound and grind these ingredients together, with strong vinegar.

No. 3. BROWN COLOR.—White glass or enamel, 1 oz.; good manganese, ½ oz.: grind together.

No. 4. RED, ROSE AND BROWN COLORS are made from peroxide of iron, prepared by nitric acid. The flux consists of borax, sand and minium, in small quantities.

RED COLOR may likewise be obtained from 1 oz. of red chalk, pounded, mixed with 2 oz. of white, hard enamel, and a little peroxide of copper.

A RED may also be composed of rust of iron, glass of antimony, yellow glass of lead, such as is used by potters (or litharge,) each in equal quantities; to which a little sulphuret of silver is added. This composition, well ground, produces a very fine red color on glass.

No. 5. GREEN.—2 oz. of brass, calcined into an oxide; 2 oz.; of minium, and 8 oz. of white sand: reduce them to a fine powder, which is to be enclosed in a well-luted crucible, and heated strongly in an air-furnace for an hour. When the mixture is cold, grind it in a brass mortar. Green may, however, be advantageously produced, by a yellow on one side, and a blue on the other. Oxide of chrome has been also employed to stain glass green.

No. 6. A FINE YELLOW STAIN.—Take fine silver, laminated thin, dissolve in nitric acid, dilute with abundance of water, and precipitate with solution of sea-salt; mix this chloride of silver in a dry powder, with three times its weight of pipe-clay, well burnt and pounded. The back of the glass pane is to be painted with this powder; for; when painted on the face, it is apt to run into the other colors.

A PALE YELLOW can be made by mixing sulphuret of silver with glass of antimony and yellow ochre, previously calcined to a red-brown tint. Work all these powders together, and paint on the back of the glass. Or silver *laminæ*, melted with sulphur, and glass of antimony, thrown into cold water, and afterwards ground to powder, afford a yellow.

A PALE YELLOW may be made with the powder resulting from brass, sulphur and glass of antimony, calcined together in a crucible till they cease to smoke, and then mixed with a little burnt ochre.

THE FINE YELLOW of M. Meraud is prepared from chloride of silver, oxide of zinc, and rust of iron. This mixture, simply ground, is applied on the glass.

ORANGE COLOR.—Take 1 part of silver-powder, as precipitated from the nitrate of that metal, by plates of copper, and washed; mix with 1 part of red ochre, and 1 of yellow, by careful trituration; grind into a thin pap, with oil of turpentine or lavender; apply this with a brush, and burn in.

Silvering Looking-Glasses with Pure Silver.—Prepare a mixture of 3 grs. of ammonia, 60 grs. nitrate of silver, 90 minims of spirits of wine, 90 minims of water; when the nitrate of silver is dissolved, filter the liquid, and add a small quantity of sugar (15 grs.,) dissolved in 1½ oz. of water and 1½ oz. spirits of wine. Put the glass into this mixture, having one side covered with varnish, gum, or some substance to prevent the silver being attached to it. Let it remain for a few days, and you have a most elegant looking-glass; yet it is far more costly than the quicksilver.

Another Method.—A sheet of tin-foil corresponding to the size of the plate of glass is evenly spread on a perfectly smooth and solid marble table, and every wrinkle on its surface is carefully rubbed down with a brush; a portion of mercury is then poured on, and rubbed over the foil with a clean piece of soft woolen stuff, after which, two rules are applied to the edges, and mercury poured on to the depth of a crown piece; when any oxide on the surface is carefully removed, and the sheet of glass, perfectly clean and dry, is slid along over the surface of the liquid metal, so that no air, dirt, or oxide can possibly either remain or get between them. When the glass has arrived at its proper position, gentle pressure is applied, and the table sloped a little to carry off the waste mercury; after which it is covered with flannel, and loaded with heavy weights; in twenty-four hours, it is removed to another table, and further slanted, and this position is progressively increased during a month till it becomes perpendicular.

Porcelain Colors.—The following are some of the colors used in the celebrated porcelain manufactory of Sevres, and the proportions in which they are compounded. Though intended for porcelain painting, nearly all are applicable to painting on glass. Flux No. 1 minium or red lead, 3 parts; white sand, washed, 1 part. This mixture is melted, by which it is converted into a greenish-colored glass. Flux No. 2. GRAY FLUX.—Of No. 1, 8 parts; fused borax in powder, 1 part; this mixture is melted. Flux No. 3. FOR CARMINES AND GREENS.—Melt together fused borax, 5 parts; calcined flint, 3 parts; pure minium, 1 part. No. 1. INDIGO BLUE. —Oxide of cobalt, 1 part; flux No. 3, 2 parts. DEEP AZURE BLUE. —Oxide of cobalt, 1 part; oxide of zinc, 2 parts; flux No. 3, 5 parts; No. 2. EMERALD GREEN.—Oxide of copper, 1 part; antimonic acid, 10 parts; flux No. 1, 30 parts; pulverize together, and melt. No. 3. GRASS GREEN.—Green oxide of chromium, 1 part; flux No. 3, 3 parts; triturate and melt. No. 4. YELLOW —Antimonic acid, 1 part; subsulphate of the peroxyde of iron, 8 parts; oxide of zinc, 4 parts; flux No. 1, 36 parts; rub together, and melt; if this color is too deep, the salt of iron is diminished. No. 5. FIXED YELLOW FOR TOUCHES.—No. 4, 1 part; white enamel of commerce, 2 parts; melt and pour out; if not sufficiently fixed, a little sand may be added. No. 6. DEEP NANKIN YELLOW.—Subsulphate of iron, 1 part; oxide of zinc, 2 parts; flux No. 2, 8 parts; triturate without melting. No. 7. DEEP RED.—Subsulphate of iron, calcined in a muffle until it becomes of a beautiful capucine red, 1 part; flux No. 2, 3 parts; mix without melting. No. 8. LIVER BROWN.—Oxide of iron made of red brown, and mixed with 3 times its weight of flux. No. 2; a tenth of sienna earth is added to it, if it is not deep enough. No. 9. WHITE.—The white enamel of commerce, in cakes. No. 10. DEEP BLACK.—Oxide of cobalt, 2 parts; copper, 2 parts; oxide of manganese, 1 part; flux No. 1, 6 parts; fused borax, ½ part; melt, and add oxide of manganese, 1 part; oxide of copper, 2 parts; triturate without melting.

THE APPLICATION —Follow the general directions given in another part of this work, in relation to staining glass.

Glass and Porcelain Gilding.—Dissolve in boiled linseed oil an equal weight either of copal or amber; add as much oil of turpentine as will enable you to apply the compound or size thus formed, as thin as possible, to the parts of the glass intended to be gilt. The glass is to be placed in a stove till it will almost burn the fingers when handled; at this temperature the size becomes adhesive, and a piece of gold-leaf, applied in the usual way, will immediately stick. Sweep off the superfluous portions of the leaf, and when quite cold it may be burnished; taking care to interpose a piece of India paper between the gold and the burnisher. See another process in a previous part of this work.

Soluble Glass.—1. Silica, 1 part; carbonate of soda, 2 parts; fuse together. 2. Carbonate of soda, (dry,) 54 parts; dry carbonate of potassa, 70 parts; silica, 192 parts; soluble in boiling water, yielding a fine transparent, semi-elastic varnish. 3. Carbonate of potassa, (dry,) 10 parts; powdered quartz (or sand, free from iron or alumina,) 15 parts; charcoal, 1 part; all fused together. Soluble in 5 or 6 times its weight of *boiling* water. The filtered solution evaportaed to dryness yields a transparent glass, permanent in the air.

To Drill and Ornament Glass.—Glass can be easily drilled by a steel drill, hardened but not drawn, and driven at a high velocity. Holes of any size, from the 16th of an inch upwards, can be drilled, by using spirits of turpentine as a dip; and, easier still, by using camphor with the turpentine. Do not press the glass very hard against the drill. If you require to ornament glass by turning in a lathe, use a good mill file and the turpentine and camphor drip, and you will find it an easy matter to produce any shape you choose.

Gilding Glass Signs, &c.—Cut a piece of thin paper to the size of your glass, draw out your design correctly in black lead-pencil on the paper, then prick through the outline of the letters with a fine needle, tie up a little dry white lead in a piece of rag; this is a pounce-bag. Place your design upon the glass, right side up, dust it with the pounce-bag; and, after taking the paper off, the design will appear in white dots upon the glass; these will guide you in laying on the gold on the opposite side, which must be *well cleaned*, preparatory to laying on the gold. PREPARING THE SIZE.—Boil perfectly clean water in an enamelled saucepan, and while boiling, add 2 or 3 shreds of best selected isinglass, after a few minutes strain it through a clean linen rag; when cool it is ready for use. CLEAN THE GLASS PERFECTLY.—When this is done, use a flat camel's-hair brush for laying on the size; and let it drain off when you put the gold on. When the gold is laid on and perfectly dry, take a ball of the finest cotton wool and gently rub or polish the gold; you can then lay on another coat of gold if desirable; it is now ready for writing. In doing this, mix a little of the best vegetable black japan; thin with turpentine to a proper working consistency; apply this when thoroughly dry; wash off the superfluous gold, and shade as in sign-writing.

Gilder's Gold Size.—Drying or boiled linseed oil, thickened with yellow ochre, or calcined red ochre, and carefully reduced to the utmost smoothness by grinding. It is thinned with oil of turpentine.

To Gild Letters on Wood, &c.—When your sign is prepared as smooth as possible, go over it with a sizing made by the white of an egg dissolved in about four times its weight of cold wafer; adding a small quantity of fuller's earth; this is to prevent the gold sticking to any part but the letters. When dry, set out the letters and commence writing, laying on the size as thinly as possible, with a sable pencil. Let it stand until you can barely feel a slight stickiness, then go to work with your gold leaf knife and cushion, and gild the letters. Take a leaf up on the point of your knife, after giving it a slight puff into the back part of your cushion, and spread it on the front part of the cushion as straight as possible, giving it another slight puff with your mouth to flatten it out. Now cut it into the proper size, cutting with the heel of your knife forwards. Now rub the tip lightly on your hair; take up the gold on the point, and place it neatly on the letters; when they are all covered get some very fine cotton wool, and gently rub the gold until it is smooth and bright. Then wash the sign with clean water to take off the egg size.

Compound Colors.—LIGHT GRAY is made by mixing white lead with lamp-black, using more or less of each material, as you wish to obtain a lighter or darker shade. BUFF is made from yellow ochre and white lead. SILVER OR PEARL GRAY.—Mix white lead, indigo, and a very slight portion of black, regulating the quantities you wish to obtain. FLAXEN GRAY is obtained by a mixture of white lead and Prussian blue, with a small quantity of lake. BRICK COLOR.—Yellow ochre and red lead, with a little white. OAK WOOD COLOR.—Three-fourths white lead and one-fourth part umber and yellow ochre, proportions of the last two ingredients being determined by the desired tints. WALNUT-TREE COLOR.—Two-thirds white lead, and one-third red ochre, yellow ochre, and umber mixed according to the shade sought. If veining is required, use different shades of the same mixture, and for the deepest places, black. JONQUIL.—Yellow, pink and white lead. This color is only proper for distemper. LEMON YELLOW.—Realgar and orpiment. The same color can be obtained by mixing yellow-pink with Naples yellow; but it is then only fit for distemper. ORANGE COLOR.—Red lead and yellow ochre. VIOLET COLOR.—Vermilion, or red lead, mixed with black or blue, and a small portion of white. Vermilion is far preferable to red lead in mixing this color. PURPLE.—Dark-red mixed with violet color. CARNATION.—Lake and white. GOLD COLOR.—Massicot, or Naples yellow, with a small quantity of realgar, and a very little Spanish white. OLIVE COLOR may be obtained by black and a little blue, mixed with yellow. Yellow-pink, with a little verdigris and lamp-black; also ochre and a small quantity of white will produce an olive color. For distemper, indigo and yellow-pink mixed with white lead or Spanish white must be used. If veined it must be done with umber. LEAD COLOR.—Indigo and white. CHESTNUT COLOR. — Red ochre and black, for a dark chestnut. To make it lighter, employ a mixture of yellow ochre. LIGHT TIMBER COLOR.—Spruce ochre, white, and a little umber. FLESH COLOR.—Lake, white lead, and a little vermilion. LIGHT WILLOW GREEN.—White mixed with verdigris. GRASS GREEN.—Yellow-pink mixed with verdigris. STONE COLOR.—White, with a little spruce ochre. DARK LEAD COLOR.—Black and white, with a little indigo. FAWN COLOR.—White lead, stone ochre, with a little vermilion. CHOCOLATE COLOR.—Lamp-black and Spanish brown. On account of the fatness of lamp-black, mix some litharge and red lead. PORTLAND STONE COLOR.—Umber, yellow ochre, and white lead.

Dyes for Veneers.—A FINE BLACK.—Put 6 lbs. of logwood chips into your copper, with as many veneers as it will hold without pressing too tight; fill it with water, let it boil slowly for about 3 hours, then add ½ lb. of *powdered verdigris*, ½ lb. copperas, bruised gall-nuts, 4 oz.; fill the copper up with vinegar, as the water evaporates; let it boil gently two hours each day till the wood is dyed through. A FINE BLUE.—Put oil of vitrol, 1 lb., and 4 oz. of the best powdered indigo, in a glass bottle. Set it in a glazed earthen pan, as it will ferment. Now put your veneers into a copper or stone trough; fill it rather more than one-third with water, and add as much of the vitriol and indigo (stirring it about) as will make fine blue, testing it with a piece of white paper or wood. Let the veneers remain till the dye has struck through. Keep the solution of indigo a few weeks before using it; this improves the color. FINE YELLOW.—Reduce 4 lbs. of the root of barberry to dust by sawing, which put in a copper or brass trough; add turmeric, 4 oz.; water, 4 gals.; then put in as many white holly veneers as the liquor will cover. Boil them together for three hours, often turning them. When cool, add aquafortis, 2 oz., and the dye will strike through much sooner. BRIGHT GREEN.—Proceed as in the previous receipt to produce a yellow; but, instead of aquafortis, add as much of the vitriolated indigo (see above, under blue dye) as will produce the desired color. BRIGHT RED.—Brazil dust, 2 lbs.; add water, 4 gals. Put in as many veneers as the liquid will cover; boil them for 3 hours, then add alum, 2 oz.; aquafortis, 2 oz.; and keep it luke-warm until it has struck through. PURPLE.—To 2 lbs. of chip logwood and ½ lb. Brazil dust, add 4 gals. of water; and after putting in your veneers, boil for 3 hours; then add pearlash, 6 oz., and alum, 2 oz.; let them boil for 2 or 3 hours every day till the color has struck through. ORANGE.—Take the veneers out of the above yellow dye, and while still wet and saturated, transfer them to the bright red dye till the color penetrates throughout.

Gilders' Pickle.—Alum and common salt, each 1 oz.; nitre, 2 oz.; dissolved in water, ½ pt. Used to impart a rich yellow color to gold surfaces. It is best used largely diluted with water.

To Silver Ivory.—Pound a small piece of nitrate of silver in a mortar, add soft water to it, mix them well together, and keep in a phial for use. When you wish to silver any article, immerse it in this solution, let it remain till it turns of a deep yellow; then place it in clear water, and expose it to the rays of the sun. If you wish to depicture a figure, name, or cipher, on your ivory, dip a camel's hair pencil in the solution, and draw the subject on the ivory. After it has turned a deep yellow, wash it well with water, and place it in the sunshine, occasionally wetting it with pure water. In a short time it will turn of a deep black color, which, if well rubbed, will change to a brilliant silver.

To Improve the Color of Stains..—Nitric acid, 1 oz.; muriatic, ½ teaspoonful; grain tin, ¼ oz.; rain water, 2 oz. Mix it at least 2 days before using, and keep your bottle well corked.

Strong Glue for Inlaying or Veneering.—Select the best light brown glue, free from clouds and streaks. Dissolve this in water, and to every pint add ½ a gill of the best vinegar and ½ oz. of isinglass.

Compound Iron Paint.—Finely pulverized iron filings, 1 part; brick dust, 1 part; and ashes, 1 part. Pour over them glue-water or size, set the whole near the fire, and, when warm, stir them well together. With this paint cover all the wood-work which may be in danger; when dry, give a second coat, and the wood will be rendered incombustible.

Best Wash for Barns and Houses.—Water lime, 1 peck; freshly slacked lime, 1 peck; yellow ochre in powder, 4 lbs.; burnt umber, 4, lbs. To be dissolved in hot water, and applied with a brush.

Durable Outside Paint.—Take 2 parts (in bulk) of water lime, ground fine; 1 part (in bulk) of white lead, in oil. Mix them thoroughly, by adding *best* boiled linseed oil, enough to prepare it to pass through a paint mill; after which, temper with oil till it can be applied with a common paint brush. Make any color to suit It will last 3 times as long as lead paint. IT IS SUPERIOR.

Farmers' Paint.—Farmers will find the following profitable for house or fence paint: skim milk, 2 quarts; fresh slacked lime, 8 oz.; linseed oil, 6 oz., white Burgundy pitch, 2 oz.; Spanish white, three pounds. The lime is to be slacked in water, exposed to the air, and then mixed with about one-fourth of the milk; the oil in which the pitch is dissolved to be added, a little at a time; then the rest of the milk, and afterwards the Spanish white. This is sufficient for 27 yards, 2 coats. This is for white paint. If desirable, any other color may be produced; thus, if a cream color is desired, in place of part of the Spanish white, use the ochre alone.

Painting in Milk.—Skimmed milk, ½ gallon; newly slacked lime, 6 oz.; and 4 oz. of poppy, linseed, or nut oil; and 5 lbs. Spanish white. Put the lime into an earthen vessel or clean bucket; and, having poured on it a sufficient quantity of milk to make it about the thickness of cream, add the oil in small quantities, a little at a time, stirring the mixture well. Then put in the rest of the milk, afterward the Spanish white finely powdered, or any other desired color. For out-door work add 2 oz. each more of oil and slacked lime, and 2 oz. of Burgundy pitch dissolved in the oil by a gentle heat.

Premium Paint, Without Oil or Lead.—Slack stone lime with boiling water in a tub or barrel to keep in the steam; then pass 6 quarts through a fine sieve. Now to this quantity add 1 quart of coarse salt, and 1 gallon of water; boil the mixture, and skim it clear. To every 5 gallons of this skimmed mixture, add 1 lb. alum; ½ lb. copperas; and by slow degrees ¾ lb. potash, and 4 quarts sifted ashes or fine sand; add any coloring desired. A more durable paint was never made.

Green Paint for Garden Stands, Blinds, Etc.—Take mineral green, and white lead ground in turpentine; mix up the quantity you wish with a small quantity of turpentine varnish. This serves for the first coat. For the second, put as much varnish in your mixture as will produce a good gloss. If you desire a brighter green, add a little Prussian blue, which will improve the color.

Milk Paint for Barns.—ANY COLOR.—Mix water lime with skim-milk, to a proper consistence to apply with a brush, and it is ready to use. It will adhere well to wood, whether smooth or rough, to brick, mortar, or stone, where oil has not been used (in which case it cleaves to some extent,) and forms a very hard substance, as durable as the best oil paint. It is too cheap to estimate, and any one can put it on who can use a brush. Any color may be given to it, by using colors of the tinge desired. If a red is preferred, mix Venetian-red with milk, not using any lime. It looks well for fifteen years.

Paint.—TO MAKE WITHOUT LEAD OR OIL.—Whiting, 5 lbs.; skimmed milk, 2 qts.; fresh slacked lime, 2 oz. Put the lime into a stone-ware vessel, pour upon it a sufficient quantity of the milk to make a mixture resembling cream; the balance of the milk is then to be added; and lastly, the whiting is to be crumbled upon the surface of the fluid, in which it gradually sinks. At this period, it must be well stirred in, or ground as you would other paint, and it is fit for use.

Substitute for White Lead.——Hard cake stearine, 100 lbs.; bleached resin, 90 lbs.; fine potato starch, 25 lbs. Melt and mix well. Then add mucilage, 20 lbs.; stir well, till nearly cool; then put away for use.

Paints, Different Sorts.—BLUE.—Blue-black, 25 lbs.; whiting, 100 lbs.; road dust, sifted, 200 lbs.; lime-water, 12 gallons. Factitious linseed oil to grind.

WHITE PAINT.—Whiting, 500 lbs.; white-lead, 400 lbs.; lime-water, 20 gallons Factitious linseed-oil to grind.

BLACK PAINT.—Ivory or lamp-black, 100 lbs.; road-dust, sifted, 200 lbs.; lime-water, 18 gallons. Oil to grind.

BROWN PAINT.—Venetian red, or Spanish brown, 1 cwt.; road-dust, 3 cwt.; common soot, 28 lbs.; lime-water, 15 lbs. Factitious linseed oil to grind.

PARIS GREEN.—Take unslacked lime of the best quality, slack it with hot water; then take the finest part of the powder, and add alum-water as strong as it can be made, sufficient to form a thick paste; then color it with bi-chromate of potash and sulphate of copper until the color suits your fancy, and dry it for use. N. B.—The sulphate of copper gives a blue tinge; the bi-chromate of potash, a yellow. Observe this, and you will get it right.

Beautiful Green Paint for Walls.—Take 4 lbs. Roman vitriol, and pour on it a tea-kettle full of boiling water. When dissolved, add 2 lbs. pearlash, and stir the mixture well with a stick until the effervescence ceases; then add ¼ lb. pulverized yellow arsenic, and stir the whole together. Lay it on with a paint-brush; and, if the wall has not been painted before, two, or even three coats will be requisite. If a pea green is required, put in less; if an apple green, more of the yellow arsenic. This paint does not cost the quarter of oil-paint, and looks better.

Blue Color for Ceilings, &c.—Boil slowly for 3 hours 1 lb. blue vitriol and ½ lb. of the best whiting in about 3 qts. water; stir it frequently while boiling, and also on taking it off the fire. When it has stood till quite cold, pour off the blue liquid, then mix the cake of color with good size, and use it with a plasterer's brush in the same manner as whitewash, either for walls or ceilings.

To Harden Whitewash.—With ½ a pail of common whitewash add ½ pint of flour. Pour on boiling water in a sufficient quantity to thicken it. Then add 6 gals. of the lime and water, and stir well.

Whitewash that will not rub off.—Mix up half a pailful of lime and water, ready to put on the wall; then take ¼ pt. of flour, mix it up with water, then pour on it the boiling water, a sufficient quantity to thicken it; then pour it while hot into the whitewash, stir all well together, and it is ready for use.

Whitewash.—The best method of making a whitewash for outside exposure is to slack half a bushel of lime in a barrel, add one pound of common salt, half a pound of the sulphate of zinc, and a gallon of sweet milk.

Substitute for Plaster of Paris.—Best whitening, 2 lbs.; glue, 1 lb.; linseed oil, 1 lb. Heat all together, and stir thoroughly. Let the compound cool, and then lay it on a stone covered with powdered whitening, and heat it well till it becomes of a tough and firm consistence; then put it by for use, covering with wet cloths to keep it fresh. When wanted for use, it must be cut in pieces adapted to the size of the mould, into which it is forced by a screw press. The ornament may be fixed to the wall, picture-frame, &c., with glue or white lead. It becomes in time as hard as stone itself.

Glue.—Powdered chalk added to common glue strengthens it. A glue which will resist the action of water is made by boiling 1 lb. of glue in 2 qts of skimmed milk.

Cheap Waterproof Glue.—Melt common glue with the smallest possible quantity of water; add, by degrees, linseed oil, rendered drying by boiling it with litharge. While the oil is added, the ingredients must be well stirred, to incorporate them thoroughly.

Fire and Waterproof Glue.—Mix a handful of quick-lime with 4 oz. of linseed oil; thoroughly lixiviate the mixture; boil it to a good thickness, and spread it on tin plates in the shade; it will become very hard, but can be dissolved over a fire, like common glue, and is then fit for use.

Prepared Liquid Glue.—Take of best white glue, 16 oz.;

white-lead, dry, 4 oz.; rain-water, 2 pts.; alcohol, 4 oz. With constant stirring, dissolve the glue and lead in the water, by means of a water-bath. Add the alcohol, and continue the heat for a few minutes. Lastly, pour into bottles, while it is still hot.

Prussian Blue.—Take nitric acid, any quantity, and as much iron shavings from the lathe as the acid will dissolve; heat the iron as hot as it can be handled with the hand; then add to it the acid in small quantities as long as the acid will dissolve it; then slowly add double the quantity of soft water that there was of acid, and put in iron again as long as the acid will dissolve it. 2. Take prussiate of potash, dissolve it in hot water to make a strong solution, and make sufficient of it with the first to give the depth of tint desired, and the blue is made. Or,—

Another Method.—A very passable Prussian blue is made by taking sulphate of iron (copperas) and prussiate of potash, equal parts of each; and dissolving each separately in water, then mixing the two waters.

Chrome Yellow .—1. Take sugar of lead and Paris white, of each 5 lbs.; dissolve them in hot water. 2. Take bi-chromate of potash, 6½ oz., and dissolve it in hot water also; each article to be dissolved separately; then mix all together, putting in the bi-chromate last. Let stand twenty-four hours.

Chrome Green.—Take Paris white, 6½ lbs.; sugar of lead, and blue vitriol, of each, 3½ lbs.; alum, 10½ oz.; best soft Prussian blue and chrome yellow, of each, 3⅓ lbs. Mix thoroughly while in fine powder, and add water, 1 gallon, stirring well and let stand three or four hours.

Green, Durable and Cheap.—Take spruce yellow, and color it with a solution of chrome yellow and Prussian blue, until you give it the shade you wish.

Another Method.—Blue vitriol, 5 lbs.; sugar of lead, 6¼ lbs.; arsenic, 2½ lbs.; bi-chromate of potash, 1½ oz.; mix them thoroughly in fine powder, and add water 3 parts, mixing well again, and let stand three or four hours.

Pea Brown.—1. Take sulphate of copper any quantity, and dissolve it in hot water. 2. Take prussiate of potash, dissolve it in hot water to make a strong solution; mix of the two solutions, as in the blue, and the color is made.

Rose Pink.—Brazil wood, 1 lb., and boil it for two hours, having 1 gallon of water at the end; then strain it, and boil alum, 1 lb., in the same water until dissolved; when sufficiently cool to admit the hand, add muriate of tin, ¾ oz. Now have Paris white, 12½ lbs.; moisten up to a salvy consistence, and when the first is cool stir them thoroughly together. Let stand twenty-four hours.

Patent Yellow.—Common salt, 100 lbs. and litharge, 400 lbs., are ground together with water, and kept for some time in a gentle heat, water being added to supply the loss by evaporation; the carbonate of soda is then washed out with more water, and the white residuum heated till it acquires a fine yellow color.

Naples Yellow.—No. 1. Metallic antimony, 12 lbs.; red lead, 8 lbs.; oxide of zinc, 4 lbs. Mix; calcine, triturate well together, and fuse in a crucible: the fused mass must be ground and elutriated to a fine powder.

Cheap Yellow Paint.—Whiting, 3 cwt.; ochre, 2 cwt.; ground white lead, 25 lbs. Factitious linseed oil to grind.

Stone Color Paint.—Road dust, 2 cwt.; ground white lead, ½ cwt.; whiting, 1 cwt.; ground umber, 14 lbs.; lime water, 6 gals. Factitious linseed oil to grind.

Glazier's Putty.—Whiting, 70 lbs.; boiled oil, 30 lbs.; water, 2 gals. Mix; if too thin, add more whiting; if too thick, add more oil.

Fish Oil Paints.—Dissolve white vitriol and litharge, of each 14 lbs., in vinegar, 32 gals.; add whale, seal, or cod oil, 1 tun, and boil to dryness, continually stirring during the ebullition. The next day, decant the clear portion; add linseed oil, 12 gals., oil of turpentine, 3 gals., mix well together. The sediment left is well agitated with half its quantity of lime water, used for some inferior paints under the name of "*prepared residue oil.*" This oil is used for various common purposes, as a substitute for linseed oil, of which the following paints are examples:—

1. Pale Green.—Lime water, 6 gals; whiting and road dust, of each, 1 cwt.; blue-black, 30 lbs.; yellow ochre, 28 lbs.; wet blue (previously ground in *prepared residue oil*,) 20 lbs.; grind well together. For use, thin with equal parts of *prepared residue oil* and linseed oil.

2. Bright Green.—Yellow ochre and wet blue, of each, 1 cwt.; road dust, 1½ cwt.; blue-black, 10 lbs.; limewater, 6 gals.; prepared fish oil, 4 gals.; prepared residue and linseed oils, of each, 7½ gals.

3. Lead Color.—Whiting, 1 cwt.; blue-black, 7 lbs.; white lead, (ground in oil,) 28 lbs ; road dust, 56 lbs.; lime water, 5 gals.; prepared residue oil, 2½ gals.

4. Reddish Brown.—Lime water, 8 gals.; Spanish brown, 1 cwt.; road dust, 2 cwt.; prepared fish, prepared residue and linseed oils, of each, 4 gals.

5. Yellow.—Substitute ochre for Spanish brown in the last receipt.

6. Black.—Substitute lamp or blue-black for Spanish brown in No. 4.

7. Stone Color.—Lime water, 4 gals.; whiting, 1 cwt.; white lead (ground in oil), 28 lbs.; road dust, 56 lbs.; prepared fish, linseed, and prepared residue oils, of each, 3 gals.

8. Chocolate.—Nos. 4 and 6 mixed together so as to form a chocolate color.

Remarks.—All the above paints require a little "driers." They are well fitted, by their cheapness, hardness, and durability, for common out-door work.

Porcelain Finish, very Hard and White for Parlors.—To prepare the wood for finish, if it be pine, give one or two coats of the "Varnish—Transparent for Wood," which prevents the pitch from oozing out, causing the finish to turn yellow; next, give the room at least four coats of pure zinc, which may be ground in only sufficient oil to enable it to grind properly; then mix to a proper consistence with turpentine or naphtha. Give each coat time to dry. When it is dry and hard, sandpaper it to a perfectly smooth surface, when it is ready to receive the finish, which consists of two coats of French zinc ground in, and thinned with Demar varnish, until it works properly under the brush.

Japan Drier, BEST QUALITY.—Take linseed oil, 1 gallon; put into it gum shellac, ¾ lb.; litharge and burned Turkey umber, each ½ lb.; red lead, ½ lb.; sugar of lead, 6 oz. Boil in the oil till all are dissolved, which will require about four hours; remove from the fire, and stir in spirits turpentine 1 gallon, and it is done.

Another.—Linseed oil, 5 gallons; add red lead and litharge, each 3½ lbs.; raw umber, 1¼ lbs.; sugar of lead and sulphate of zinc, each ½ lb.; pulverize all the articles together, and boil in the oil till dissolved; when a little cool, thin with turpentine, 5 gallons.

Drying Oil Equal to Patent Driers at One Quarter their Price.—Linseed oil, 2 gallons; red lead and umber, each, 4 oz.; sulphate of zinc, 2 oz.; sugar of lead, 2 oz. Boil until it will scorch a feather, when it is ready for use.

Prepared Oil for Carriages, &c.—To 1 gallon linseed oil add 2 lbs. gum shellac; litharge, ½ lb.; red lead, ¼ lb.; umber, 1 oz. Boil slowly as usual until the gums are dissolved; grind your paints in this (any color,) and reduce with turpentine. Yellow ochre is used in floor painting.

Drying Oils. 1.—Nut or linseed oil, 1 gal.; litharge, 12 oz; sugar of lead and white vitriol, of each 1 oz.; simmer and skim until a pellicle forms; cool, and, when settled, decant the clear. 2. Oil, 1 gal.; litharge, 12 to 16 oz.; as last. 3. Old nut or linseed oil, 1 pint; litharge, 3 oz. Mix; agitate occasionally for 10 days; then decant the clear. 4. Nut oil and water, of each 2 lbs.; white vitriol, 2 oz.; boil to dryness. 5. Mix oil with powdered snow or ice, and keep it for 2 months without thawing.

To reduce Oil Paint with Water.—Take 8 lbs. of pure unslacked lime, add 12 qts. water, stir it and let it settle, turn it off gently and bottle it, keep it corked till used. This will mix with oil, and in proportion of half will render paint more durable.

Oil Paint.—TO REDUCE WITH WATER.—Gum shellac, 1 lb.; sal-soda, ½ lb.; water, 3 parts; boil all together in a kettle, stirring till dissolved. If it does not all dissolve, add a little more sal-soda; when cool, bottle for use; mix up 2 quarts of oil paint as usual, any color desired, using no turpentine; put 1 pint of the gum shellac mixture with the oil paint when it becomes thick; it can then be reduced with water to a proper thickness to lay on with a brush.

Another Method.—Soft water, 1 gallon; dissolve it in pearlash, 3 oz.; bring to a boil, and slowly add shellac, 1 lb.; when cold it is ready to be added to oil paint in equal proportions.

How to build Gravel Houses.—This is the best building material in the world. It is four times cheaper than wood, six times cheaper than stone, and superior to either. Proportions for mixing: To eight barrows of slacked lime, well deluged with water, add 15 barrows of sand; mix these to a creamy consistency, then add 60 barrows of coarse gravel, which must be worked well and completely; you can then throw stones into this mixture, of any shape or size, up to ten inches in diameter. Form moulds for the walls of the house by fixing boards horizontally against upright standards which must be immovably braced so that they will not yield to the immense pressure outwards as the material settles; set the standards in pairs around the building where the walls are to stand, from six to eight feet apart, and so wide that the inner space shall form the thickness of the wall, Into the moulds thus formed throw in the concrete material as fast as you choose, and the more promiscuously the better. In a short time the gravel will get as hard as the solid rock.

Flexible Paint for Canvas.—Yellow soap, 2½ lbs., boiling water, 1½ gals., dissolve; grind the solution while hot with *good oil paint*, 1¼ cwt. Use for canvas.

Painter's Cream.—Pale nut oil, 6 oz., mastic, 1 oz., dissolve; add of sugar of lead, ¼ oz., previously ground in the least possible quantity of oil, then add of water *q. s.*, gradually, until it acquires the consistency of cream, working it well all the time. Used to cover the unfinished work of painters. It will wash off with water.

Mastic Cement for Covering the Fronts of Houses.—Fifty parts, by measure, of clean dry sand, fifty of limestone (not burned) reduced to grains like sand, or marble dust, and ten parts of red lead, mixed with as much boiled linseed oil as will make it slightly moist. The bricks to receive it should be covered with three coats of boiled oil, laid on with a brush, and suffered to dry before the mastic is put on. It is laid on with a trowel like plaster, but it is not so moist. It becomes hard as stone in a few months. Care must be exercised not to use too much oil.

Cement for Outside of Brick Walls.—Cement for the outside of brick walls, to imitate stone, is made of clean sand, 90 parts; litharge, 5 parts; plaster of Paris, 5 parts; moistened with boiled linseed oil. The bricks should receive two or three coats of oil before the cement is applied.

Cement for Tile Roofs.—Equal parts of whiting and dry sand, and 25 per cent. of litharge, made into the consistency of putty with linseed oil. It is not liable to crack when cold, nor melt, like coal-tar and asphalt, with the heat of the sun.

Excellent Cheap Roofing.—SHINGLES SUPERSEDED.—Have your roof stiff. rafters made of stuff 1½ by 8 inches, well supported and 6 feet apart, with ribs 1 inch by 2 inches, set edgeways, well nailed to the rafters, about 18 inches apart. The boards may be thin, but must be well seasoned, and nailed close together; this done, lay down and cover the roof with thin, soft, spongy straw paper used in making paper-boxes, which comes in rolls, and comes very low. Lay in course up and down the roof, and lap over, nailing down with common No. 6 tacks, with leather under the heads like carpet-tacks. Then spread on several coatings of the following composition, previously boiled, stirred, and mixed together: good clean tar, 8 gals.; Roman cement, 2 gals. (or in its place very fine, clean sand may be used;) resin, 5 lbs.; tallow, 3 lbs.; apply hot; and let a hand follow, and shift on sharp grit sand, pressing it into the tar composition. If wished fire-proof, go over the above with the following preparation: Slake stone lime under cover with hot water till it falls into a fine powder; sift and mix 6 qts. of this with 1 qt. salt, add 2 gals. water, boil and skim. To 5 gals. of this add 1 lb. alum, and 1½ lbs. of copperas, and slowly, while boiling, 1½ lbs. potash, and 4 qts. of clean, sharp sand, and any coloring desired. Apply a thick coat with a brush, and you may have a roof which no fire can injure from the outside.

Water Lime at Fifty Cents per Barrel.—Fine, clean sand, 100 lbs.; quick lime in powder, 28 lbs.; bone-ashes, 14 lbs.; for use, beat up with water, and use as quick as possible.

To Render Wood Indestructible.—ROBBINS'S PROCESS.—This seems to be a process of inestimable value, and destined to produce very important results. The apparatus used consists of a retort or still, which can be made of any size or form, in which resin, coal tar, or other oleaginous substances, together with water, are placed in order to subject them to the action of heat. Fire being applied beneath the retort containing the coal tar, &c., oleaginous vapor commences to rise, and pass out through a connecting pipe into a large iron tank or chamber (which can also be built of any size), containing the timber, &c., to be operated upon. The heat acts at once on the wood, causing the sap to flow from every pore, which, rising in the form of steam, condenses on the body of the chamber, and discharges through an escape pipe in the lower part. In this process a temperature of 212° to 250° Fahr. is sufficient to remove the surface moisture from the wood; but after this the temperature should be raised to 300° or more, in order to completely saturate and permeate the body of the wood with the antiseptic vapors and heavier products of the distillation. The hot vapor coagulates the albumen of the wood, and opens the pores, so that a large portion of the oily product or creosote is admitted; the contraction resulting from the cooling process hermetically seals them, and decay seems to be almost impossible. There is a man hole in the retort, used to change or clean out the contents; and the wood chamber is furnished with doors made perfectly tight. The whole operation is completed in less than one hour, rendering the wood proof against rot, parasites, and the attacks of the *Teredo navilis* or naval worm.

Cement for Seams In Roofs.—Take equal quantities of white lead and white sand, and as much oil as will make it into the consistence of putty. It will in a few weeks become as hard as stone.

Roman Cement.—Drift sand, 84 parts; unslacked lime, 12 lbs.; and 4 lbs. of the poorest cheese grated; mix well; add hot (not boiling) water to reduce to a proper consistence for plastering. Work well and quick with a thin, smooth coat.

Smalt.—Roast cobalt ore to drive off the arsenic; make the residuum into a paste with oil of vitriol, and heat it to redness for an hour; powder, dissolve in water, and precipitate the oxide of iron by carbonate of potash, gradually added until a rose-colored powder begins to fall; then decant the clear, and precipitate by a solution of silicate of potash prepared by fusing together for 5 hours a mixture of 10 parts of potash, 15 parts of finely ground flints, and 1 part charcoal. The precipitate, when dry, may be fused and powdered very fine.

Fictitious Linseed Oil.—Fish or vegetable oil, 100 gallons; acetate of lead, 7 lbs.; litharge, 7 lbs.; dissolved in vinegar, 2 gallons. Well mixed with heat, then add boiled oil, 7 gallons; turpentine, 1 gallon. Again well mix.

Varnishes.—COMMON OIL VARNISH.—Resin, 4 lbs.; beeswax, ½ lb.; boiled oil, 1 gallon; mix with heat; then add spirits turpentine, 2 quarts.

MASTIC VARNISH.—Mastic, 1 lb.; white wax, 1 oz.; spirits turpentine, 1 gallon; reduce the gums small; then digest it with heat in a close vessel till dissolved.

TURPENTINE VARNISH.—Resin, 1 lb.; boiled oil, 1 lb.; melt; then add turpentine, 2 lbs. Mix well.

PALE VARNISH.—Pale African copal, 1 part; fuse. Then add hot pale oil, 2 parts. Boil the mixture till it is stringy; then cool a little, and add spirits turpentine, 3 parts.

LACQUER VARNISH.—A good lacquer is made by coloring lacquer varnish with turmeric and annotto. Add as much of these two coloring substances to the varnish as will give it the proper color; then squeeze the varnish through a cotton cloth, when it forms lacquer.

Deep Gold-Colored Lacquer.—Seed lac, three ounces; turmeric, one ounce; dragon's blood, one-fourth ounce; alcohol, one pint; digest for a week, frequently shaking; decant, and filter.

Lacquers are used upon polished metals and wood to impart the appearance of gold. If yellow is required, use turmeric, aloes, saffron, or gamboge; for red, use annotto, or dragon's blood, to color. Turmeric, gamboge, and dragon's blood generally afford a sufficient range of colors.

Gold Varnish.—Digest shellac, sixteen parts gum sandarach mastic, of each three parts; crocus, one part; gum gamboge, two parts; all bruised, with alcohol, one hundred and forty-four parts. Or, digest seedlac, sandarach, mastic, of each eight parts; gamboge, two parts; dragon's blood, one part; white turpentine, six parts; turmeric, four parts; bruised with alcohol one hundred and twenty parts.

Gold Lacquer.—Put into a clean four-gallon tin 1 pound of ground turmeric, 1½ ozs. of gamboge, 3½ lbs. of powdered gum sandarach, ¾ of a lb. of shellac, and two gallons of spirits of wine. When shaken, dissolved, and strained, add 1 pint of turpentine varnish, well mixed.

Polish for Turner's Work.—Dissolve sandarach, 1 oz., in spirits of wine, ½ pt.; next shave beeswax, 1 oz.; and dissolve it in a sufficient quantity of spirits turpentine to make it into a paste; add the former mixture by degrees to it, then with a woolen cloth apply it to the work while it is in motion in the lathe, and with a soft linen rag polish it. It will appear as if highly varnished.

Varnish for Tools.—Take tallow, 2 oz.; resin, 1 oz., and melt together. Strain while hot to get rid of specks which are in the resin; apply a slight coat on your tools with a brush, and it will keep off rust for any length of time.

Gold Varnish.— Turmeric, 1 dram; gamboge, 1 dram; turpentine, 2 pints; shellac, 5 oz.; sandarach, 5 oz.; dragon's blood, 8 drams; thin mastic varnish, 8 oz.; digest with occasional agitation for 14 days; then set it aside to fine, and pour off the clear.

Book-Binder's Varnish. — Shellac, eight parts; gum benzoin, 3 parts; gum mastic, two parts; bruise, and digest in alcohol, 48 parts; oil of lavender, ½ part. Or, digest shellac, 4 parts; gum mastic, 2 parts; gum dammer and white turpentine, of each 1 part; with alcohol (95 per cent.), 28 parts.

Beautiful Pale Amber Varnish.—Amber, pale and transparent, 6 lbs.; fuse; add hot clarified linseed oil, 2 gals.; boil till it strings strongly, cool a little, and add oil of turpentine, 4 gals. This soon becomes very hard, and is the most durable of oil varnishes. When wanted to dry quicker, drying oil may be substituted for linseed, or "driers" may be added during the cooling.

Black Coach-Varnish.—Amber, 1 lb.; fuse; add hot *drying* oil, ½ pt.; powdered black resin and Naples asphaltum, of each 3 oz. When properly incorporated and considerably cooled, add oil of turpentine, 1 pt.

Body Varnish.—Finest African copal, 8 lbs.; fuse carefully; add clarified oil, 2 gals.; boil gently for 4½ hours, or until quite stringy; cool a little, and thin with oil of turpentine, 3½ gals. *Dries slowly.*

Carriage Varnish.— Sandarach, 19 oz.; pale shellac, 9½ oz.; very pale transparent resin, 12½ oz.; turpentine, 18 oz.; 85 per cent. alcohol, 5 pts.; dissolve. Used for the internal parts of carriages, &c. Dries in ten minutes.

Cabinet-Maker's Varnish.—Very pale shellac, 5 lbs.; mastic, 7 oz.; alcohol, 90 per cent, 5 or 6 pts.; dissolve in the cold with frequent stirring. Used for French polishing, &c.

Japanner's Copal Varnish.—Pale African copal, 7 lbs; fuse;

add clarified linseed oil, ½ gal.; boil five minutes, remove it into the open air; add boiling oil of turpentine, 3 gals.; mix well, strain it into the cistern, and cover it up immediately. Used to varnish furniture, and by japanners, coachmakers, &c.

Copal Varnish.—Pale, hard copal, 8 lbs.; add hot and pale drying oil, 2 gals.; boil till it strings strongly, cool a little, and thin with hot rectified oil of turpentine, 3 gals.; and strain immediately into the store can. Very fine.

Gold Varnish of Watin, for Gilded Articles.—Gumlac in grains, gamboge, dragon's blood, and annotto, of each 12½ oz.; saffron, 3⅓ oz. Each resin must be dissolved separately in 5 pts. of 90 per cent. alcohol, and two separate tinctures must be made with the dragon's blood and annotto in a like quantity of spirit; and a proper proportion of each mixed together to produce the required shade.

Varnish for Plaster Casts.—White soap and white wax, each ½ oz.; water, 2 pts.; boil together in a clean vessel for a short time. This varnish is to be applied when cold with a soft brush.

Transparent Varnish for Ploughs, &c.—Best alcohol, 1 gal.; gum sandarach, 2 lbs.; gum mastic, ½ lb.; place all in a tin can which admits of being corked; cork tight, shake it frequently, occasionally placing the can in hot water. When dissolved, it is ready for use.

Fine Black Varnish for Coaches.—Melt in an iron pot, amber, 32 oz,; resin, 6 oz.; asphaltum, 6 oz.; drying linseed oil, 1 pt.; when partly cooled, add oil of turpentine, warmed, 1 pint.

Mordant Varnish.—Dissolve 1 oz. mastic, 1 oz. sandarach, ½ oz. gum gamboge, and ¼ oz. turpentine in 6 oz. spirits turpentine. One of the simplest mordants is that procured by dissolving a little honey in thick glue. It has the effect of greatly heightening the color of the gold, and the leaf sticks extremely well.

Changing Varnish.—To IMITATE GOLD OR SILVER, &C. Put 4 oz. best gum gamboge into 32 oz. spirits of turpentine; 4 oz. dragon's blood into 32 oz. spirits turpentine, and 1 oz. of annotto into 8 oz. spirits turpentine. Make the 3 three mixtures in different vessels. Keep them in a warm place, exposed to the sun as much as possible, for about 2 weeks, when they will be fit for use. Add together such quantities of each liquor as the nature of the color you are desirous of obtaining will point out.

Varnish, Transparent, for Wood.—Best alcohol, 1 gal.; nice gum shell, 2½ lbs. Place the jug or bottle in a situation to keep it just a little warm, and it will dissolve quicker than if hot, or left cold.

Patent Varnish for Wood or Canvas.—Take spirits of turpentine, 1 gal.; asphaltum, 2¼ lbs.; put them into an iron kettle which will fit upon a stove, and dissolve the gum by heat. When dissolved and a little cool, add copal varnish, 1 pt.; and boiled linseed oil, 1 pt.; when cold it is ready for use. Perhaps a little lampblack would make it a more perfect black.

Beautiful Varnish for Violins, &c.—Rectified spirits of wine, ½ gal.; add 6 oz. gum sandarach, 3 oz. gum mastic, and ½ pint turpentine varnish; put the above in a tin can by the stove, frequently shaking till well dissolved; strain, and keep for use. If you find it harder than you wish, thin with more turpentine-varnish.

Crimson Satin for Musical Instruments.—Ground Brazil wood, 1 lb.; water, 3 quarts; cochineal, ½ ounce; boil the Brazil with the water for an hour, strain, add the cochineal, boil gently for half an hour, when it will be fit for use. If you wish a *scarlet tint*, boil an ounce of saffron in a quart of water, and pass over the work before you stain it.

urple Satin.—Chipped logwood, 1 lb.; water, 3 quarts; pearl-ash, 4 ounces; powdered indigo, 2 ounces. Boil the logwood in the water half an hour, add the pearl-ash and indigo, and when dissolved you will have a beautiful purple.

Green Stain.—Strong vinegar, 3 pints; best verdigris, 4 oz. ground fine; sap green, ½ ounce; mixed together.

Black Stains for Wood.—1. Drop a little sulphuric acid into a small quantity of water; brush over the wood, and hold it to the fire; it will be a fine black, and receive a good polish. 2. For a beautiful black on wood, nothing can exceed the *black Japan* mentioned under Tinsmith's Department. Apply two coats; after which, varnish and polish it. 3. To 1 gallon vinegar, add a quarter of a pound of iron-rust; let it stand for a week; then add a pound of dry lamp-black, and three quarters of a pound of copperas; stir it up for a couple of days. Lay on five or six coats with a sponge, allowing it to dry between each; polish with linseed oil and a soft woolen rag, and it will look like ebony. Incomparable for iron work, ships' guns, shot, &c. 4. Vinegar, ½ gallon; dry lamp-black, ½ lb.; iron-rust sifted, 3 lbs.; mix, and let stand for a week. Lay three coats of this on hot, and then rub with linseed oil, and you will have a fine deep black. 5. Add to the above stain nut-galls, 1 oz.; logwood chips, ½ lb.; copperas, ¼ lb,; lay on three coats; oil well, and you will have a black stain that will stand any kind of weather, and is well adapted for ships' combings, &c. 6. Logwood chips, 1 lb.; Brazil wood, ¼ lb.; boil for 1½ hours in one gallon water. Brush the wood with this decoction while hot; make a decoction of nutgalls, by simmering gently, for three or four days, a quarter of a pound of the galls in 2 quarts water; give the wood three coats, and, while wet, lay on a solution of sulphate of iron (2 oz. to a quart,) and, when dry, oil or varnish. 7. Give three coats with a solution of copper-filings in aquafortis, and repeatedly brush over with the logwood decoction until the greenness of the copper is destroyed. 8. Boil ½ lb. logwood chips in 2 quarts water; add an ounce of pearl-ash, and apply hot with a brush. Then take 2 quarts of the logwood decoction, and ½ oz. of verdigris, and the same of copperas; strain, and throw in ½ lb. of iron-rust. Brush the work well with this, and oil.

Rose-wood Stain, Light Shade.—Equal parts of logwood and red-wood chips; boil well in water sufficient to make a strong stain; apply it to the furniture while hot, 2 or 3 coats, according to the depth of color desired.

Rose Pink Stain and Varnish.—Put 1 oz. of potash in 1 qt. water, with red sanders, 1½ oz.; extract the color from the wood, and strain; then add gum shellac, ½ lb.; dissolve it by a brisk fire. Used upon logwood stain for rosewood imitation.

Blue Stain for Wood.—1. Dissolve copper-filings in aquafortis, brush the wood with it, and then go over the work with a hot solution of pearlash (2 oz. to 1 pint water) till it assumes a perfectly blue color. 2. Boil 1 lb. of indigo, 2 lbs. wood, and 3 oz. alum, in 1 gallon water; brush well over until thoroughly stained.

Imitation of Botany Bay Wood.—Boil ½ lb. of French berries (the unripe berries of the *Rhamnus infectorius*) in 2 quarts water till of a deep yellow, and, while boiling hot, give two or three coats to the work. If a deeper color is desired, give a coat of logwood decoction over the yellow. When nearly dry, form the grain with No. 8 *black stain*, used hot; and, when dry, rust and varnish.

Mahogany Color.—DARK.—1. Boil ½ lb. of madder and 2 oz. logwood chips in a gallon of water, and brush well over while hot; when dry, go over the whole with pearlash solution, 2 drs. to the quart. 2. Put 2 oz. dragon's blood, bruised, into a quart of oil of turpentine; let the bottle stand in a warm place; shake frequently, and, when dissolvod, steep the work in the mixture.

Box Wood Brown Stain.—Hold your work to the fire, that it may receive a gentle warmth; then take aquafortis, and, with a feather, pass it over the work till you find it change to a fine brown (always keeping it near the fire;) you may then varnish or polish it.

Light Brown Red.—Boil ½ lb. madder and ¼ lb. fustic in 1 gal. water; brush over the work, when boiling hot, until properly stained. 2. The surface of the work being quite smooth, brush over with a weak solution of aquafortis, ½ oz. to the pint; then finish with the following: Put 4½ oz. dragon's blood and 1 oz. soda, both well bruised, to 3 pints spirits of wine; let it stand in a warm place, shake frequently, strain, and lay on with a soft brush, repeating until of a proper color. Polish with linseed oil or varnish.

Purple.—Brush the work several times with the logwood decoction used for *No. 6 Black;* and, when dry, give a coat of pearlash solution, 1 drachm to a quart; lay it on evenly.

Red.—1. Boil 1 lb. Brazil wood and 1 oz. pearlash in 1 gallon water; and, while hot, brush over the work until of a proper color. Dissolve 2 oz. alum in 1 quart water, and brush the solution over the work before it dries. 2. Take a gallon of the above stain, add 2 oz. more pearlash; use hot, and brush over with the alum solution. 3. Use a cold solution of archil, and brush over with the pearlash solution used for No. 1 *dark mahogany*.

Ebony Stain.— Infuse gall-nuts in vinegar wherein you have soaked rusty nails; then rub your wood with this; let it dry, polish and burnish.

Bright Yellow Stain. — 1. Brush over with the tincture of turmeric. 2. Warm the work, and brush it over with weak aquafortis; varnish or oil as usual. 3. A very small bit of aloes put into the varnish will give a rich yellow color to the wood.

Extra Black Stain for Wood.—Pour 2 qts. boiling water over 1 oz. of powdered extract of logwood, and, when the solution is effected, 1 dr. of yellow chromate of potash is added, and the whole well stirred. It is then ready for use as a wood-stain, or for writing ink. When rubbed on wood, it produces a pure black. Repeat with two, three, or four applications, till a deep black is produced, which acquires the highest beauty when polished or stained.

Imitation of Mahogany.—Let the first coat of painting be white lead; the second, orange; and the last, burnt umber or sienna; imitating the veins according to your taste and practice.

To Imitate Wainscot.— Let the first coat be white; the second, half white and half yellow; and the third, yellow ochre only; shadow with umber or sienna.

To Imitate Satin Wood.—Take white for your first coating, light blue for the second, and dark blue or dark green for the third.

Rosewood Satin, very Bright Shade. — USED COLD. — Take alcohol, 1 gal.; camwood, 2 oz.; set them in a warm place, 24 hours; then add extract of logwood, 3 oz.; aquafortis, 1 oz.; and when dissolved it is ready for use; it makes a very bright ground, like the most beautiful rosewood; one, two, or more coats as you desire, over the whole surface.

Varnish for Frames, Etc. — Lay the frames over with tin or silver foil by means of plaster of Paris, or cement of some kind, that the foil may be perfectly adherent to the wood; then apply your gold lacquer varnish, which is made as follows: ground turmeric, 1 lb.; powdered gamboge, 1½ ounces; powdered sandarach, 3½ lbs.; powdered shellac, ¾ lb.; spirits of wine, 2 gals.; dissolve, and strain; then add turpentine varnish, 1 pt.; and it is ready for use.

Cherry Stain.—Rain water, 3 qts.; annotto, 4 oz.; boil in a copper kettle till the annotto is dissolved, then put in a piece of potash the size of a walnut, keep it on the fire about half an hour longer, and it is ready to bottle for use.

Black Walnut Stain. — New, very cheap, sinks deep, and very good imitation. Dissolve permanganate of potash in water; about 1 oz. to a pailful. Vary to suit the taste. If bought in quantities, this stain should not cost over 50 cents per barrel.

Miscellaneous Stains.—YELLOW is produced by diluted nitric acid. RED is produced by a solution of dragon's blood in spirits of wine. BLACK is produced by a strong solution of nitric acid. GREEN is produced by a solution of verdigris in nitric acid. Then dipped in a hot solution of pearlash produces a BLUE stain. PURPLE is produced by a solution of sal-ammoniac in nitric acid.

Finishing with one Coat of Varnish.—VALUABLE PROCESS.—Give the furniture a coat of boiled linseed oil, then immediately sprinkle dry starch upon it, and rub it in well with your hand, or a stiff brush, all over the surface; the starch absorbs the oil, and fills the pores of the wood completely. For black walnut, add a little burned umber to the starch; for cherry, a little Venetian red, &c., according to the color of the wood. Turned work can have it applied while in motion in the lathe. Furniture can afterwards be finished with only one coat of varnish.

Polishes.—CARVER'S POLISH.—White resin, 2 oz.; seed lac, 2 oz.; spirits of wine, 1 pt. Dissolve. It should be laid on warm. Avoid moisture and dampness when used.

2. FRENCH POLISH.—Gum shellac, 1 oz.; gum arabic, ¼ oz.; gum copal, ¼ oz. Powder, and sift through a piece of muslin; put them in a closely corked bottle with 1 pt. spirits of wine, in a very warm situation, shaking every *day* till the gums are dissolved; then strain through muslin, and cork for use.

3. POLISH FOR DARK-COLORED WOODS.—Seed lac, 1 oz.; gum guaiacum, 2 drs.; dragon's blood, 2 drs.; gum mastic, 2 drs.; put in a bottle with 1 pt. spirits of wine, cork close, expose to a moderate heat till the gums are dissolved; strain into a bottle for use, with ¼ gill of linseed oil; shake together.

4. WATER-PROOF POLISH.—Gum benjamin, 2 oz.; gum sandarach, ¼ oz.; gum anima, ¼ oz.; spirits of wine, 1 pt. Mix in a closely stopped bottle, and place either in a sand bath or in hot water till the gums are dissolved, then strain off the mixture, shake it up with a ¼ gill of the best clear poppy oil, and put it by for use.

5. FINISHING POLISH.—Gum shellac, 2 drs.; gum benjamin, 2 drs.; put into ½ pint of best rectified spirits of wine in a bottle closely corked, keep in a warm place, shaking frequently till the gums are dissolved. When cold, shake up with it two teaspoonfuls of the best clear poppy oil.

Polish for Removing Stains, Spots, and Mildew from Furniture.—Take of 98 per cent. alcohol, ½ pt.; pulverized resin and gum shellac, of each, ¼ oz. Let these cut in the alcohol; then add linseed oil, ½ pt.; shake well, and apply with a sponge, brush, or cotton flannel, or an old newspaper, rubbing it well after the application, which gives a nice polish.

Polish for Reviving Old Furniture, Equal to the "Brother Jonathan."—Take alcohol, 1½ oz.; spirits of salts (muriatic acid), ½ oz.; linseed oil, 8 oz.; best vinegar, ½ pt.; and butter of antimony, 1½ oz.; mix, putting in the vinegar last.

Jet or Polish fer Wood or Leather, Black, Red, or Blue.—Alcohol (98 per cent.), 1 pt.; sealing wax, the color desired, 3 sticks; dissolve by heat, and have it warm when applied. A sponge is the best to apply it with.

Furniture Fillings.—1. Beeswax, spirits of turpentine and linseed oil, equal parts; melt and cool. 2. Beeswax, four oz.; turpentine, 10 oz.; alkanet root, to color; melt and strain. 3. Beeswax, 1 lb.; linseed oil, 5 oz.; alkanet root, one-half ounce; melt, add 5 oz. of turpentine; strain and cool. 4. Beeswax, 4 oz; resin, 1 oz.; oil of turpentine, 2 oz.; Venetian red, to color.

Furniture Polish.—Beeswax, ½ lb.; and a ¼ oz. of alkanet root; melt together in a pipkin until the former is well colored. Then add linseed oil and spirits of turpentine, of each ½ a gill; strain through a piece of coarse muslin.

French Polishes.—1. Shellac, 3 lbs.; wood naphtha, 3 pts.; dissolve. 2. Shellac, 2 lbs.; powdered mastic and sandarach, of each, 1 oz.; copal varnish, ½ pt.; spirits of wine, 1 gal. Digest in the cold till dissolved.

Furniture Fillings.—1. Turpentine, 1 pt.; alkanet root, ½ oz.; digest until sufficiently colored, then add beeswax, scraped small, 4 oz.; put the vessel into hot water, and stir till dissolved. If wanted *pale*, the alkanet root should be omitted. 2 (*White.*) White wax, 1 lb.; liquor of potassa, ½ gal.; boil to a proper consistence. 3. Beeswax, 1 lb.; soap, ¼ lb.; pearlash, 3 oz. (dissolved in water, ½ gal., and strained,) boil as last. 4. Yellow wax, 16 parts; resin, 1 part; alkanet root, 1 part; turpentine, 6 parts; linseed oil, 6 parts. First steep the alkanet in the oil with heat, and, when well colored, pour off the clear on the other ingredients, and again heat till all are dissolved.

Furniture Cream.—Beeswax, 1 lb.; soap, 4 oz.; pearlash, 2 oz.; soft water, 1 gal., boil together until mixed.

Furniture Oils.—1. Acetic acid, 2 dr.; oil of lavender, ½ dr.; rectified spirit, 1 dr.; linseed oil, 4 oz. 2. Linseed oil, 1 pt.; alkanet root, 2 oz.; heat, strain and add lac varnish, 1 oz. 3. Linseed oil, 1 pt.; rectified spirit, 2 oz.; butter of antimony, 4 oz.

Mosaic Gold Powder for Bronzing.—Melt 1 lb. tin in a crucible, and ½ lb. of purified quicksilver to it; when this is cold, it is reduced to powder, and ground, with ½ lb. sal-ammoniac and 7 oz. flour of sulphur, till the whole is thoroughly mixed. They are then calcined in a matrass; and the sublimation of the other ingredients leaves the tin converted into the mosaic gold powder which is found at the bottom of the glass. Remove any black or discolored particles. The sal-ammoniac used must be very white and clear, and the mercury of the utmost purity. When a deeper red is required, grind a very small quantity of red lead with the above materials.

True Gold Powder.—Put some gold-leaf, with a little honey, or thick gum-water made with gum arabic, into an earthen mortar, and pound the mixture till the gold is reduced to very small particles; then wash out the honey or gum repeatedly with warm water, and the gold in powder will be left behind. When dry, it is fit for use.

Dutch Gold Powder is made from Dutch gold-leaf, which is sold in books at a very low price. Treat in the manner described above for true gold powder. When this inferior powder is used, cover the gilding with a coat of clear varnish, otherwise it will soon lose its bright appearance.

Copper Powder is prepared by dissolving filing or slips of copper with nitrous acid in a receiver. When the acid is saturated, the slips are to be removed; or, if filings be employed, the solution is to be poured off from what remains undissolved. Small bars are then put in, which will precipitate the copper powder from the saturated acid; and, the liquid being poured from the powder, this is to be washed clean of the crystals by repeated waters.

General Directions for Bronzing.—The choice of the above powders is, of course, determined by the degree of brilliancy you wish to obtain. The powder is mixed with strong gum-water or isinglass, and laid on with a brush or pencil; and, when not so dry as to have still a certain clamminess, a piece of soft leather wrapped round the finger is dipped in the powder, and rubbed over the work. When the work has been all covered with the bronze, it must be left to dry, and any loose powder then cleared away by a hair-pencil.

The Bronzing of Plaster Casts is effected by giving them a coat of oil or size varnish, and when this is nearly dry applying with a dabber of cotton or a camel hair-pencil any of the metallic bronze powders; or the powder may be placed in a little bag of muslin, and dusted over the surface, and afterwards finished with a wad of linen. The surface must be afterwards varnished.

Bronzing Iron.—The subject should be heated to a greater degree than the hand can bear, and German gold, mixed with a small quantity of spirit-of-wine varnish, spread over it with the pencil; should the iron be already polished, you must heat it well, and moisten it with a linen rag dipped in vinegar.

French Burnished Gilding.—*Encollage,* or glue coat.—To a decoction of wormwood and garlic in water, strained through a cloth, a little common salt and some vinegar are added. This is mixed with as much good glue, and the mixture spread in a hot state with a brush of boar's hair. When plaster or marble is gilded, leave out the salt. The first glue-coating is made thinner than the second. 2. *White preparation* consists in covering the above surface with 8, 10, or 12 coats of Spanish white, mixed up with strong size; each well worked on with the brush. 3. *Stop* up the pores with thick whiting and glue, and smooth the surface with dog-skin. 4. *Polish* the surface with pumice-stone and very cold water. 5. *Retouch* the whole in a skilful manner. 6. *Cleanse* with a damp linen rag, and then a soft sponge. 7. *Rub* with a horse's tail (*shave-grass*) the parts to be yellowed, to make them softer. 8. *Yellow* with *yellow ochre* carefully ground in water, and mixed with transparent colorless size. Use the thinner part of the mixture with a fine brush. 9. Next rub the work with shave-grass to remove any granular appearance. 10. *Gold-water size* consists of Armenian bole, 1 lb.; bloodstone (hematite), 2 oz.; and as much galena, each separately ground in water. Then mix all together with a spoonful of olive oil. This is tempered with a white sheep-skin glue, clear and well strained. Heat and apply three coats with a fine long-haired brush. 11. *Rub* with a clean, dry linen cloth, except the parts to be burnished, which are to receive other two coats of the gold size, tempered with glue. 12. The surface damped with cold water (iced in summer), has then the *gold-leaf* applied to it. Gild the *hollow* ground before the more prominent parts; water being dexterously applied by a soft brush, immediately behind the gold-leaf, before laying it down; removing any excess of water with a dry brush. 13. *Burnish* with bloodstone. 14. Next pass a thin coat of glue, slightly warmed, over the parts that are not to be burnished. 15. Next moisten any broken points with a brush, and apply bits of gold-leaf to them. 16. Apply the *vermeil* coat very lightly over the gold-leaf with a soft brush. It gives lustre and fire to the gold, and is made as follows: annotto, 2 oz.; gamboge, 1 oz.; vermilion, 1 oz.; dragon's blood, ½ oz.; salt of tartar, 2 oz.; saffron, 18 grs.; boil in 2 English pints of water, over a slow fire, till it is reduced to a fourth; then pass the whole through silk or muslin sieve. 17. Next pass over the dead surfaces a second coat of deadening glue, hotter than the first. This finishes the work and gives it strength.

Bronzing or Gilding Wood.—Pipe clay, 2 oz.; Prussian blue, patent yellow, raw umber, lampblack, of each, 1 oz.: grind separately with water on a stone, and as much of them as will make a good color put into a small vessel three-fourths full of size. The wood, being previously cleaned and smoothed, and coated with a mixture of clean size and lampblack, receives a new coating twice successively, with the above compound, having allowed the first to dry. Afterwards the bronze powder is to be laid on with a pencil, and the whole burnished or cleaned anew, observing to repair the parts which may be injured by this operation; next the work must be coated over with a thin layer of Castile soap, which will take the glare off the burnishing; and afterwards be carefully rubbed with a woolen cloth. The superfluous powder may be rubbed off when dry.

Bronze Powder of a PALE GOLD color is produced from an alloy of 13¼ parts of copper, and 2¾ parts zinc, of a CRIMSON METALLIC LUSTRE from copper, of a *paler color*, copper, and a very little zinc; GREEN bronze with a proportion of verdigris, of a fine ORANGE color, by 14½ parts copper and 1¾ zince; another ORANGE color, 13¾ parts copper and 2¼ zinc. The alloy is laminated into very fine leaves with careful annealing, and these are levigated into impalpable powders, along with a film of fine oil, to prevent oxidizement, and to favor the levigation.

Reviver for Gilt Frames.—White of eggs, 2 oz.; chloride of potash or soda, 1 oz.; mix well, blow off the dust from the frames; then go over them with a soft brush dipped in the mixture, and they will appear equal to new.

Gilding on Wood.—To gild in oil, the wood after being properly smoothed, is covered with a coat of *gold size*, made of drying linseed oil mixed with yellow ochre; when this has become so dry as to adhere to the fingers without soiling them, the gold leaf is laid on with great care and dexterity, and pressed down with cotton wool; places that have been missed are covered with small pieces of gold leaf, and when the whole is dry, the ragged bits are rubbed off with the cotton. This is by far the easiest mode of gilding: any other metallic leaves may be applied in a similar manner. PALE LEAF GOLD has a greenish yellow color, and is an alloy of gold and silver. Dutch gold leaf is only copper leaf colored with the fumes of zinc; being much cheaper than true gold leaf, it is very useful when large quantities of gilding are required in places where it can be defended from the weather, as it changes color if exposed to moisture; and it should be covered with varnish. SILVER LEAF is prepared every way the same as gold leaf; but when applied should be kept well covered with varnish, otherwise it is liable to tarnish; a transparent yellow varnish will give it the appearance of gold. Whenever gold is fixed by means of linseed oil, it will bear washing off, which burnished gold will not.

Best Color for Boot, Shoe, and Harness Edge.—Alcohol, 1 pint; tincture of iron, 1½ oz.; extract logwood, 1 oz.; pulverized nutgalls, 1 oz.; soft water, ½ pint; sweet oil, ½ oz.; put this last into the alcohol before adding the water. Nothing can exceed the beautiful finish imparted to the leather by this preparation. The only objection is the cost.

Cheap Color for the Edge.—Soft water, 1 gallon; extract logwood, 1 oz.; boil till the extract is dissolved; remove from the fire, and add copperas, 2 oz.; bi-chromate of potash and gum arabic, of each, ½ oz.; all to be pulverized.

Superior Edge Blacking.—Soft water, 5 gallons; bring to a boil, and add 8 oz. logwood extract, pulverized; boil 3 minutes, remove from the fire, and stir in 2½ oz. gum arabic, 1 oz. bi-chromate of potash, and 80 grains prussiate of potash.

For a small quantity of this, use water, 2 quarts; extract of logwood, ¾ oz.; gum arabic, 96 grains; bi-chromate of potash, 48 grains; prussiate of potash, 8 grains. Boil the extract in the water 2 minutes; remove from the fire, and stir in the others; and it is ready for use.

For tanners' surface blacking, which is not required to take on a high polish, the gum arabic may be omitted.

Sizing for Boots and Shoes in Treeing Out.—Water, 1 quart; dissolve in it by heat, isinglass, 1 oz.; adding more water to replace loss by evaporation; when dissolved, add starch, 6 oz.; extract of logwood, beeswax, and tallow, of each 2 oz. Rub the starch up first by pouring on sufficient boiling water for that purpose. It makes boots and shoes soft and pliable, and gives a splendid appearance to old stock on the shelves.

Black Varnish for the Edge.—Take 98 per cent. alcohol, 1 pint; shellac, 3 oz.; resin, 2 oz.; pine turpentine, 1 oz.; lamp-black, ¼ oz.; mix; and when the gums are all cut, it is ready for use. This preparation makes a most splendid appearance when applied to boot, shoe, or harness edge, and is equally applicable to cloth or wood, where a gloss is required after being painted.

Best Harness Varnish Extant.—Alcohol, 1 gallon; white turpentine, 1½ lbs.; gum shellac, 1½ lbs.; Venice turpentine, 1 gill. Let them stand by the stove till the gums are dissolved, then add sweet oil, 1 gill; and color if you wish it with lamp-black, 2 oz. This will not crack like the old varnish.

Another.—Isinglass, or gelatine, and indigo, of each, ¼ oz.; logwood, 4 oz.; soft soap, 2 oz ; glue, 4 oz.; vinegar, 1 pint; mix by heat, and strain.

Brilliant French Varnish for Leather.—Spirit of wine, ¾ pint; vinegar, 5 pints; gum senegal in powder, ½ lb.; loaf sugar, 6 oz.; powdered galls, 2 oz.; green copperas, 4 oz. Dissolve the gum and sugar in the water; strain, and put on a slow fire, but don't boil; now put in the galls, copperas, and the alcohol; stir well for five minutes; set off; and when nearly cool strain through flannel, and bottle for use. It is applied with a pencil brush. Most superior.

Liquid Japan for Leather.—Molasses, 8 lbs.; lamp-black, 1 lb.; sweet oil, 1 lb.; gum arabic, 1 lb.; isinglass, 1 lb. Mix well in 32 lbs. water; apply heat; when cool, add 1 quart alcohol; an ox's gall will improve it.

Waterproof Oil Blacking.—Camphene, 1 pint; add all the India rubber it will dissolve; currier's oil, 1 pint; tallow, 7 lbs.; lamp-black, 2 oz. Mix thoroughly by heat.

Shoemaker's Heel Ball.—Beeswax, 8 oz.; tallow, 1 oz.; melt, and add powdered gum arabic, 1 oz., and lamp-black to color.

Cement for Leather or Rubber Soles and Leather Belting.—Gutta percha, 1 lb.; India rubber, 4 oz.; pitch, 2 oz.; shellac, 1 oz.; oil, 2 oz.; melt and use hot.

Oil Paste Blacking.—Ivory black, 4 lbs.; molasses, 3 lbs.; sweet oil, 1 lb.; oil vitriol, 3 lbs.; mix, and put in tins.

To Dye Leather Blue, Red, or Purple.—For *red*, steep it in alum water, then pass it through a warm decoction of Brazil wood; *blue*, steep in an indigo vat; *purple*, steep the skins in alum water, then put it in a warm decoction of logwood.

Gold Varnish.—Turmeric, 1 drachm; gamboge, 1 drachm; turpentine, 2 pints; shellac, 5 oz.; sandarach, 5 oz.; dragon's blood, 8 drachms; thin mastic varnish, 8 oz.; digest with occasional agitation for fourteen days; then set aside to fine, and pour off the clear.

Grain Black for Harness Leather.—First stain in tallow; then take spirits turpentine, 1 pint; cream of tartar, 1 oz.; soda, 1 oz.; gum shellac, ½ oz.; thick paste reduced thin, 2 quarts. Mix well. This will finish 12 sides.

Stains for Wood and Leather.—RED.—Brazil wood, 11 parts; alum, 4 parts; water, 85 parts. Boil.

BLUE.—Logwood, 7 parts; blue vitriol, 1 part; water, 22 parts. Boil.

BLACK.—Logwood, 9 parts; sulphate of iron, 1 part; water, 25 parts. Boil.

GREEN.—Verdigris, 1 part; vinegar, 3 parts. Dissolve.

YELLOW.—French berries, 7 parts; water, 10 parts; alum, 1 part. Boil.

PURPLE.—Logwood, 11 parts; alum, 3 parts; water, 29 parts. Boil.

Deer Skins.—TANNING AND BUFFING FOR GLOVES.—For each skin take a bucket of water, and put into it 1 quart of lime; let the skin or skins lie in from 3 to 4 days; then rinse in clean water, hair, and grain; then soak them in cold water to get out the glue; now scour or pound in good soap-suds for half an hour; after which take white vitriol, alum, and salt, 1 tablespoon of each to a skin; these will be dissolved in sufficient water to cover the skin, and remain in it for 24 hours; wring out as dry as convenient, and spread on with a brush ½ pint of currier's oil, and hang in the sun about two days; after which you will scour out the oil with soap-suds, and hang out again until perfectly dry; then pull and work them until they are soft; and if a reasonable time does not make them soft, scour in suds again as before, until complete. The oil may be saved by pouring or taking it from the top of the suds, if left standing for a short time. The buff color is given by spreading yellow ochre evenly over the surface of the skin, when finished, rubbing it in well with a brush.

TANNING WITH ACID.—After having removed the hair, scouring, soaking, and pounding in the suds, &c., as in the last recipe, in place of the white vitriol, alum, and salt, as there mentioned, take oil of vitriol (sulphuric acid,) and water, equal parts of each, and thoroughly wet the flesh side of the skin with it, by means of a sponge or cloth upon a stick; then folding up the skin, letting it lie for 20 minutes only, having ready a solution of sal-soda and water, say 1 lb. to a bucket of water, and soak the skin or skins in that for two hours, when you will wash in clean water, and apply a little dry salt, letting lie in the salt over night, or that length of time; then remove the flesh with a blunt knife, or, if doing business on a large scale, by means of the regular beam and flesh-knife; when dry or nearly so, soften by pulling and rubbing with the hands, and also with a piece of pumice-stone. This, of course, is the quickest way of tanning, and by only wetting the skins with the acid, and soaking them out in 20 minutes, they are not rotted.

Another Method.—Oil of vitriol, ½ oz.; salt, 1 teacup; milk sufficient to handsomely cover the skin, not exceeding 3 qts., warm the milk, then add the salt and vitriol; stir the skin in the liquid 40 minutes, keeping it warm; then dry, and work it as directed in No. 4.

Liquid Red.—Channellers will find that no better or richer color for their purposes can be got than the red ink described under the Grocer's Department, diluted to the required shade. For color for the bottoms of shoes use tincture of red sanders.

Bridle Stain.—Skimmed milk, 1 pint; spirits of salts, ½ oz.; spts. of red lavender, ½ oz.; gum arabic, 1 oz.; and the juice of 2 lemons; mix well together, and cork for use; apply with a a sponge; when dry, polish with a brush or a piece of flannel. If wished paler, put in less red lavender.

Process of Tanning Calf, Kip, and Harness Leather in from Six to Thirty Days.—For a 12 lb. calf skin, take 3 lbs. of terra japonica, common salt 2 lbs.; alum, 1 lb.; put them into a copper kettle with sufficient water to dissolve the whole by boiling. The skin will be limed, haired, and treated every way as for the old process, when it will be put it into a vessel with sufficient water to cover it, at which time you will put in 1 pint of the composition stirring it well, adding the same amount each night and morning for 3 days, when you will add the whole, handling 2 or 3 times daily all the time tanning; you can continue to use the tanning liquid by adding half the quantity each time, by keeping these proportions for any amount. If you desire to give a bark color to the leather, you will put in 1 lb. of Sicily sumac; kip skins will require about 20 days, light house hides for harness 30 days, calf skins from 6 to 10 days at most.

To Tan Raw Hide.—When taken from the animal, spread it flesh side up; then put 2 parts of saltpetre and alum combined, make it fine, sprinkle it evenly over the surface, roll it up, let it alone a few days till dissolved; then take off what flesh remains, and nail the skin to the side of a barn in the sun; stretch tight, to make it soft like harness leather, put neat's foot oil on it, fasten it up in the sun again; then rub out all the oil you can with a wedge-shaped stick, and it is tanned with the hair on.

French Finish for Leather.—Take a common wooden pailful of scraps (the legs and pates of calf skins are best), and put a handful each of salt and alum upon them, and let them stand 3 days; then boil them until they get a thick paste; in using, you will warm it, and in the first application put a little tallow with it, and for the second time a little soft soap, and use it in the regular way of finishing, and your leather will be soft and pliable, like French leather.

French Patent Leather.—Work into the skin with appropriate tools 3 or 4 successive coatings of drying varnish, made by boiling linseed oil with white lead and litharge, in the proportion of 1 lb. of each of the latter to 1 gal. of the former, and adding a portion of chalk or ochre, each coating being thoroughly dried before the application of the rest. Ivory black is then substituted for the chalk or ochre, the varnish thinned with spirits of turpentine, and five additional applications made in the same manner as before, except that it is put on thin and not worked in. The leather is rubbed down with pumice stone, in powder, and then placed in a room at 90 degrees, out of the way of dust. The last varnish is prepared by boiling ½ lb. of asphaltum with 10 lbs. of the drying oil used in the first stage of the process, and then stirring in 5 lbs. copal varnish and 10 lbs. of turpentine. It must have 1 month's age before using.

Cheap Tanning without Bark or Mineral Astringents.—The astringent liquor is composed of water, 17 gals.; Aleppo galls, ½ lb.; Bengal catechu, 1½ oz. and 5 lbs. of tormentil, or septfoil root. Powder the ingredients, and boil in the water 1 hour; when cool, put in the skins (which must be prepared by being plunged into a preparation of bran and water for 2 days previously); handle them frequently during the first 3 days, let them alone the next 3 days, then handle 3 or 4 times in one day; let them lie undisturbed for 25 days more, when the process will be complete.

Canadian Process.—The Canadians make 4 liquors in using the japonica.

The FIRST liquor is made by dissolving, for 20 sides of upper, 15 lbs. of terra japonica in sufficient water to cover the upper being tanned. The SECOND liquor contains the same amount of japonica, and 8 lbs. of saltpetre also. The THIRD contains 20 lbs. of japonica, and 4½ lbs. of alum. The FOURTH liquor contains only 15 lbs. of japonica, and 1½ lbs. of sulphuric acid; and the leather remains 4 days in each liquor for upper; and for sole the quantities and time are both doubled. They count 50 calf skins in place of 20 sides of upper, but let them lie in each liquor only 3 days.

Fifty Dollar Recipe for Tanning Fur and Other Skins.—Remove the legs and useless parts, soak the skin soft, and then remove the fleshy substances, and soak it in warm water one hour. Now take for each skin borax, saltpetre, and Glauber-salt, of each ½ oz. and dissolve or wet with soft water sufficient to allow it to be spread on the flesh side of the skin. Put it on with a brush, thickest in centre or the thickest part of the skin, and double the skin together, flesh side in; keeping it in a cool place for 24 hours, not allowing it to freeze. Then wash the skin clean, and take sal-soda, 1 oz.; borax, ½ oz.; refined soap, 2 oz.; melt them slowly together, being careful not to allow them to boil, and apply the mixture to the flesh side as at first. Boil up again, and keep in a warm place for 24 hours; then wash the skin clean again, as above, and have saleratus, 2 oz.; dissolved in hot rain water sufficient to well saturate the skin; then take alum, 4 oz.; salt, 8 oz.; and dissolve also in hot rain water; when sufficiently cool to allow the handling of it without scalding, put in the skin for 12 hours; then wring out the water, and hang up for 12 hours more to dry. Repeat this last soaking and drying two or three times, according to the desired softness of the skin when finished. Lastly, finish by pulling and working, and finally by rubbing with a piece of pumice stone and fine sand paper. This works like a charm on sheep skins, fur skins, dog, wolf, bear skins, &c.

French Polish or Dressing for Leather.—Mix 2 pints best vinegar with 1 pt. soft water; stir into it ¼ lb. glue, broken up, ½ lb. logwood chips, ¼ oz. of finely powdered indigo, ¼ oz. of the best soft soap, ¼ oz. of isinglass; put the mixture over the fire, and let it boil ten minutes or more; then strain, bottle and cork. When cold, it is fit for use. Apply with a sponge.

Currier's Size.—Take of sizing, 1 qt.; soft soap, 1 gill; stuffing, 1 gill; sweet milk, ½ pt.; boil the sizing in water to a proper consistence, strain, and add the other ingredients; and when thoroughly mixed, it is ready for use.

Currier's Paste.—FIRST COAT.—Take of water, 2 qts.; flour, ½ pint; Castile soap, 1 oz.; make into paste. SECOND COAT.—Take of first paste, ½ pt.; gum tragacanth, 1 gill; water, 1 pt.; mix all together. This will finish eighteen sides of upper.

Currier's Skirting.—This is for finishing skirting and the flesh of harness leather, in imitation of oak tanning. Take of chrome yellow, ½ lb.; yellow ochre, 1 lb.; cream of tartar, 1 oz.; soda, ½ oz.; paste, 5 qts.; mix well. This will finish twelve sides.

Skirting.—For the grain to imitate oak tan. Take of chrome yellow, ½ lb.; yellow ochre, ½ lb.; cream of tartar, 1 oz.; soda, 1 oz.; paste, 2 qts.; spirits of turpentine, 1 pt.; mix well. This will finish twelve sides.

Dyes for Leather.—BLUE.—For each skin, take 1 oz. of indigo, put it into boiling water, and let it stand one night; then warm it a little, and with a brush smear the skin twice over, and finish the same as the red.

RED.—After the skin has been properly prepared with sheep, pigs' dung, &c., then take strong alum water, and sponge over your skin; when dry, boil a strong gall liquor (it cannot be too strong); then boil a strong Brazil wood liquor (the stronger the better); take a sponge, dip it into your liquor, and sponge it over your skin; repeat this till it comes to a full red. To finish your skin, take the white of eggs, and a little gum dragon, mix the two together in half a gill of water, sponge over your skin, and, when dry, polish off.

YELLOW.—1. Infuse quercitron bark in vinegar, in which put a little alum, and brush over your skins with the infusion; finish the same as the red. 2. Take 1 pt. of whisky, 4 oz. turmeric; mix them well together; when settled sponge your skins over, and finish as above.

BLACK.—Put your skin on a clean board, sponge it over with gall and sumach liquors, strong; then take a strong logwood liquor, sponge it over three or four times; then take a little copperas, mix it in the logwood liquor; sponge it over your skin, and finish it the same as the red.

PURPLE.—First sponge with the alum liquor strong, then with logwood liquor strong; or mix them both, and boil them, and sponge with the liquor, finish the same as the red. The pleasing hues of yellow, brown, or tan color, are readily imparted to leather by the following simple process: Steep saffron in boiling water for a number of hours, wet a sponge or soft brush in the liquor, and with it smear the leather. The quantity of saffron, as well as of water, will, of course, depend on how much dye may be wanted, and their relative proportions to the depth of color required.

To Marble Books or Paper.—Marbling of books or paper is performed thus: Dissolve four ounces of gum arabic in two quarts of fair water; then provide several colors mixed with water in pots or shells, and with pencils peculiar to each color; sprinkle them by way of intermixture upon the gum water, which must be put into a trough, or some broad vessel; then, with a stick, curl them, or draw them out in streaks to as much variety as may be done. Having done this, hold your book or books close together, and only dip the edges in, on the top of the water and colors, very lightly; which done, take them off, and the plain impression of the colors, in mixture, will be upon the leaves; doing as well the ends as the front of the book in like manner, and afterwards glazing the colors.

Bookbinder's Varnish.—Shellac, eight parts; gum benzoin, 3 parts; gum mastic, two parts; bruise, and digest in alcohol, forty-eight parts; oil of lavender, one-half part. Or digest shellac, four parts; gum mastic, two parts; gum dammer and white turpentine, of each, one part; with alcohol (95 per cent.,) twenty-eight parts.

Red Sprinkle for Bookbinder's Red.—Brazil wood (ground,) 4 parts; alum, 1 part; vinegar, 4 parts; water, 4 parts. Boil until reduced to 7 parts, then add a quantity of loaf sugar and gum; bottle for use.

BLUE.—Strong sulphuric acid, 8 oz.; Spanish indigo, powdered, 2 oz.; mix in a bottle that will hold a quart, and place it in a warm bath to promote solution. For use, dilute a little to the required color in a tea-cup.

BLACK.—No better black can be procured than that made by the receipt for surface blacking, in this work, which see.

ORANGE COLOR.—Ground Brazil wood, 16 parts; annotto, 4 parts; alum, sugar, and gum arabic, each 1 part; water, 70 parts; boil, strain, and bottle.

PURPLE.—Logwood chips, 4 parts; powdered alum, 1 part; soft water, 24 parts; boil until reduced to 16 parts, and bottle for use.

GREEN.—French berries, 1 part; soft water, 8 parts. Boil and add a little powdered alum; then bring it to the required shade of green by adding liquid blue.

BROWN.—Logwood chips, 1 part; annotto, 1 part; boil in water, 6 parts; if too light, add a piece of copperas the size of a pea.

Tree Marble.—A marble in the form of trees may be done by bending the boards a little on the centre, using the same method as the common marble, having the covers previously prepared. The end of a candle may be rubbed on different parts of the board to form knots.

RICE-MARBLE.—Color the cover with spirits of wine and turmeric, then place on rice in a regular manner, throw on a very fine sprinkle of copperas water till the cover is nearly black, and let it remain till dry. The cover may be spotted with the red liquid or potash water, very freely, before the rice is thrown off the boards.

SPOTTED MARBLE FOR BOOKS, ETC.—After the fore-edge of the book is cut, let it remain in the press, and throw on linseeds in a regular manner, sprinkle the edge with any dark color till the paper is covered, then shake off the seeds. Various colors may be used; the edge may be colored with yellow or red before throwing on the seeds, and sprinkling with blue. The seeds will make a fine fancy edge when placed very thick on different parts, with a few slightly thrown on the spaces between.

JAPAN COLORING FOR LEATHER, BOOK-COVERS, ETC.—After the book is covered and dry, color the cover with potash water mixed with a little paste; give two good coats of Brazil wash, and glaze it; put the book between the hands, allowing the boards to slope a little; dash on copperas water, then with a sponge full of red liquid press out on the back and on different parts large drops, which will run down each board and make a fine shaded red; when the cover is dry, wash it over two or three times with Brazil wash to give it a brighter color. See the various dyes for leather under that head.

To make Paper into Parchment.—To produce this transformation, take unsized paper and plunge it into a solution of two parts of concentrated sulphuric acid combined with 1 part water; withdraw it immediately, and wash it in clean water, and the change is complete. It is now fit for writing; for the acid supplies the want of size, and it becomes so strong that a strip 2 or 3 inches wide will bear from 60 to 80 lbs. weight, while a like strip of parchment will bear only about 25 lbs.

Best Cement for Aquaria.—It is the same as that used in constructing the tanks of the Zoological Gardens, London. One part, by measure, say a gill of litharge; 1 gill of plaster of Paris; 1 gill of dry, white sand; ⅓ of a gill of finely powdered resin. Sift, and keep corked tight until required for use, when it is to be made into a putty by mixing in boiled oil (linseed) with a little patent drier added. Never use it after it has been mixed (that is, with the oil) over fifteen hours. This cement can be used for marine as well as fresh-water aquaria, as it resists the action of salt water. The tank can be used immediately, but it is best to give it three or four hours to dry.

Horn in Imitation of Tortoise Shell.—First steam and then press the horn into proper shapes, and afterwards lay the following mixture on with a small brush, in imitation of the mottle of tortoise-shell: Take equal parts of quick-lime and litharge, and mix with strong soap-lees; let this remain until it is thoroughly dry; brush off, and repeat two or three times if necessary. Such parts as are required to be of a reddish brown should be covered with a mixture of whiting and the stain.

Dyes for Ivory, Horn, and Bone.—BLACK.—1. Lay the articles for several hours in a strong solution of nitrate of silver, and expose to the light. 2. Boil the article for some time in a strained decoction of logwood, and then steep it in a solution of per-sulphate or acetate of iron. 3. Immerse frequently in ink until of sufficient depth of color.

BLUE.—1. Immerse for some time in a dilute solution of sulphate of indigo, partly saturated with potash, and it will be fully stained. 2. Steep in a strong solution of sulphate of copper.

GREEN.—1. Dip blue-stained articles for a short time in nitro-hydrochlorate of tin, and then in a hot decoction of fustic. 2. Boil in a solution of verdigris in vinegar until the desired color is obtained.

RED.—1. Dip the articles first in a tin mordant, used in dyeing, and then plunge into a hot decoction of Brazil wood—half a pound to a gallon of water—or cochineal. 2. Steep in red ink till sufficiently stained.

SCARLET.—Use lac-dye instead of the preceding.

VIOLET.—Dip in the tin mordant, and then immerse in a decoction of logwood.

YELLOW.—Boil the articles in a solution of alum, 1 lb. to ½ a gallon, then immerse for half an hour in the following mixture: Take a ½ lb. of turmeric, and a ¼ lb. of pearlash; boil in 1 gal. water: when taken from this, the bone must be again dipped in the alum solution.

Etching Fluid for Ivory.—Take dilute sulphuric acid, dilute muriatic acid, equal parts: mix. For etching varnish take white wax, 2 parts; tears of mastic, 2 parts: mix.

To Gild Ivory.—Immerse it in a solution of nitro-muriate of gold, and then expose it to hydrogen gas while damp. Wash it afterwards in clean water.

To Soften Ivory.—In 3 oz. spirits of nitre, and 15 oz. of spring water, mixed together, put your ivory to soak; and in three or four days it will obey your fingers.

To Whiten Ivory.——Slack some lime in water; put your ivory in that water, after being decanted from the grounds, and boil it till it looks quite white. To polish it afterwards, set it in the turner's wheel; and, after having worked, take rushes and pumice stones, subtile powder, with water, and rub it till it looks perfectly smooth. Next to that, heat it by turning it against a piece of linen or sheepskin leather; and, when hot, rub it over with a little whitening diluted in oil of olive; then, with a little dry whitening alone; finally with a piece of soft white rag. When all this is performed as directed, the ivory will look very white.

Another Way to Bleach Ivory.——Take 2 handfuls of lime, slake it by sprinkling it with water; then add 3 pints of water, and stir the whole together; let it settle ten minutes, and pour the water into a pan for your purpose. Then take your ivory and steep it in the lime-water for 24 hours, after which, boil it in a strong alum-water for 1 hour, and dry it in the air.

To Cut and Polish Marble.—The marble saw is a thin plate of soft iron, continually supplied, during its sawing motion, with water and the sharpest sand. The sawing of moderate pieces is performed by hand; but that of large slabs is most economically done by a proper mill. The first substance used in the polishing process is the sharpest sand, which must be worked with till the surface becomes perfectly flat. Then a second, and even a third sand, of increasing fineness is to be applied. The next substance is emery, of progressive degrees of fineness; after which, tripoli is employed; and the last polish is given with tin putty. The body with which the sand is rubbed upon the marble is usually a plate of iron; but, for the subsequent process, a plate of lead is used, with fine sand and emery. The polishing rubbers are coarse linen cloths, or bagging, wedged tight into an iron planing tool. In every step of the operation, a constant trickling supply of water is required.

Alabaster, Marble, or Stone may be stained of a yellow, red, green, blue, purple, black, or any of the compound colors, by the stains used for wood.

Powerful Cement for Broken Marble.—Take gum Arabic, 1 lb.; make into a thick mucilage; add to it powdered plaster of Paris, 1½ lbs.; sifted quick-lime, 5 oz.; mix well; heat the marble, and apply the mixture.

Seven Colors for Staining Marble.—It is necessary to heat the marble hot, but not so hot as to injure it, the proper heat being that at which the colors nearly boil. BLUE.—Alkaline indigo dye, or turnsole with alkali.

RED.—Dragon's blood in spirits of wine.

YELLOW.—Gamboge in spirits of wine.

GOLD COLOR.—Sal-ammoniac, sulphate of zinc, and verdigris, equal parts.

GREEN.—Sap green, in spirits of potash.

BROWN.—Tincture of logwood.

CRIMSON.—Alkanet root in turpentine. Marble may be veined according to taste. To stain marble *well* is a difficult operation.

Perpetual Ink for Tombstones, Etc.——Pitch, 11 lbs.; lamp-black, 1 lb.; turpentine sufficient; mix with heat.

To Clean Old Marble.—Take a bullock's gall, 1 gill of soap lees, half a gill of turpentine; make into a paste with pipe-clay, apply it to the marble; let it dry a day or two, then rub it off, and it will appear equal to new; if very dirty, repeat the application.

To Remove Grease.——Aqua ammonia, 2 oz.; soft water, 1 qt.; saltpetre, 1 teaspoonful; shaving soap in shavings, 1 oz.; mix all together; dissolve the soap well, and any grease or dirt that cannot be removed with this preparation nothing else need be tried for it.

To Clean Marble.—Take two parts of common soda, 1 part pumice stone, and 1 part of finely powdered chalk; sift it through a fine sieve, and mix it with water; then rub it well all over the marble, and the stains will be removed; then wash the marble over with soap and water, and it will be as clean as it was at first.

To make a Chemical Barometer.—Take a long, narrow bottle, and put into it 2½ drs. of camphor; spirits of wine, 11 drs. When the camphor is dissolved, add to it the following mixture: Water, 9 drs.; saltpetre, 38 grs.; sal-ammoniac, 38 grs. Dissolve these salts in the water prior to mixing with the camphorated spirit; then shake all well together, cork the bottle well, wax the top, but afterwards make a very small aperture in the cork with a red-hot needle. By observing the different appearances which the materials assume as the weather changes, it becomes an excellent prognosticator of a coming storm or of a sunny sky.

Waterproofing for Clothing.—Boiled oil, 15 lbs.; beeswax, 1 lb.; ground litharge, 13 lbs.; mix, and apply with a brush to the article, previously stretching against a wall or on a table, previously well washing and drying each article before applying the composition.

To Renew Old Silks.—Unravel and put them in a tub, cover them with cold water, let them remain one hour; dip them up and down, but do not wring; hang up to drain, and iron while very damp, and it will look beautiful.

Potter's Invisible Waterproofing for Clothing.—Imbue the cloth on the wrong side with a solution of isinglass, alum, and soap dissolved in water, forming an emulsion of a milky thickness; apply with a brush, rubbing in well. When dry, it is brushed on the wrong side against the grain, and then gone over with a brush dipped in water; afterwards brushed down smooth.

To raise a Nap on Cloth.—Clean the article, well; soak it in cold water for half an hour; put it on a board, and rub the threadbare parts with a half-worn hatter's card filled with flocks, or with a teazle or a prickly thistle until a nap is raised; then lay the nap the right way with a hatter's brush, and hang up to dry.

Black Reviver for Cloth.—Bruised galls, 1 lb.; logwood, 2 lbs.; green vitriol, ½ lb.; water, 5 quarts; boil two hours; strain, and it is ready for use.

Trapper's and Angler's Secret for Game and Fish.—A few drops of oil of anise, or oil rhodium, on any trapper's bait, will entice any wild animal into the snare trap. India cockle mixed with flour dough, and sprinkled on the surface of still water, will intoxicate fish, render them insensible; when coming up to the surface, they can be lifted into a tub of fresh water to revive them, when they may be used without fear.

Easy Method of Preventing Moths in Furs or Woolens.—Sprinkle the furs or woolen stuffs, as well as the drawers or boxes in which they are kept, with spirits of turpentine, the unpleasant scent of which will speedily evaporate on exposure of the stuffs to the air. Some persons place sheets of paper, moistened with spirits of turpentine, over, under, or between pieces of cloth, &c., and find it a very effectual method. Many woolen drapers put bits of camphor, the size of a nutmeg, in papers, on different parts of the shelves in their shops; and as they brush their cloths every two, three, or four months, this keeps them free from moths; and this should be done in boxes where furs, &c., are put. A tallow candle is frequently put within each muff when laid by.

Clothing Renovator.—Soft water, 1 gal.; make a strong decoction of logwood by boiling the extract with the water. Strain; when cool, add 2 oz.; gum arabic in powder; bottle, cork well, and set aside for use; clean the coat well from grease and dirt, and apply the above liquid with a sponge evenly. Dilute to suit the color, and hang in the shade to dry; afterwards brush the nap smooth, and it will look like new.

Waterproofing for Porous Cloth.—Dissolve 2½ lbs. alum in 4 gals. water; dissolve also, in a separate vessel the same weight of acetate of lead in the same quantity of water. When both are well dissolved, mix the solutions together; and, when the sulphate of lead resulting from this mixture has been precipitated to the bottom of the vessel in the form of a powder, pour off the solution, and plunge into it the fabric to be rendered waterproof. Wash and rub it well during a few minutes, and hang it in the air to dry.

How to Write on Glass in the Sun.—Dissolve chalk in aqua fortis to the consistency of milk, and add to that a strong solution of silver. Keep this in a glass decanter well stopped. Then cut out from a paper the letters you would have appear, and paste the paper on the decanter or jar, which you are to place in the sun in such a manner that its rays may pass through the spaces cut out of the paper, and fall on the surface of the liquor. The part of the glass through which the rays pass will turn black, while that under the paper will remain white. Do not shake the bottle during the operation. Used for lettering jars.

To Transfer Prints, Etc., to Glass.—Take of gum sandarach, 4 oz.; mastic, 1 oz.; Venice turpentine, 1 oz.; alcohol, 15 oz. Digest in a bottle, frequently shaking, and it is ready for use. Directions: Use, if possible, good plate-glass of the size of the picture to be transferred, go over it with the above varnish, beginning at one side, press down the picture firmly and evenly as you proceed, so that no air can possibly lodge between; put aside, and let it dry perfectly, then moisten the paper cautiously with water, and remove it piece-meal by rubbing carefully with the fingers; if managed nicely, a complete transfer of the picture to the glass will be effected.

Paper for Photographing.—Wash the paper with a solution of nitrate of silver, 5 grs.; distilled water, ½ oz.; dry the paper, and wash it with iodide of potassium, 5 grs.; distilled water, ½ oz.; dry with a gentle heat; repeat the wash with the silver solution; and, when dry, the paper is ready for use. The sensitive surface is an iodide of silver, and is easily affected by light.

How to Photograph on Glass.—Take dry saltpetre, ½ oz.; strong oil vitriol, ¾ oz.; mix in a tumbler, add 20 grains of dry cotton wool, stir with a glass rod five minutes, remove the cotton, and wash from all traces of the acid in four or five waters; then dry carefully under 120°. This is gun cotton. To make collodion, dissolve 20 grs. gun-cotton in 6 oz. sulphuric ether, to which add alcohol, ¾ oz.; let it stand a short time, and pour off the clear into bottle No. 1 for use. In bottle No. 2, put 1 oz. alcohol, and as much iodide of ammonium as it will dissolve; then add as much iodide of silver (made from nitrate of silver and iodide of potassium) as the solution will take up. Get another bottle, No. 3, with a wide mouth; into it put 1 oz. out of No. 1, to which add 15 or 20 drops out of No. 2. The collodion thus formed is call collodio-iodide of silver. Having well cleaned a plate of glass of the size of the frame in your camera, coat it completely and very evenly on one side, by pouring the collodion on the centre from the bottle; pour back any excess of liquid from one corner of the glass, and in this way you coat the plate in a uniform manner. To prepare the plate thus coated for the camera, plunge it carefully and quickly into a bath of the following proportions, then allow it to remain covered in the solution about two minutes: Distilled water, 1 oz.; nitrate of silver, 80 grs.; alcohol, 30 drops; dissolve and filter. Obtain a good focus, place the plate in the frame and the frame in the camera, pull up the slide in front, and expose a proper length of time; having closed your slide, remove the frame to your dark room, take out the plate, and develop the picture with the following solution, holding the plate perfectly level, the collodion side upward, and pouring enough of it on the plate to cover it; in a short time the picture will be developed: Water, 1 oz.; copperas, 14 grs.; saltpetre, 10 grs.; acetic acid, ½ drachm; nitric acid, 2 drops; then wash with water, and pour over it some of the solution of hyposulphite of soda made thus: Water, 1 pt.; hyposulphate of soda, 4 oz., allow it to remain for two minutes, then wash off thoroughly, and your picture is finished. By this process, a most beautiful picture is obtained in a space of time varying from a fraction of a second up to 15 seconds, with the most perfect detail of all the parts.

Bottle Glass.—No. 1. DARK GREEN.—Fused glauber-salts, 11 lbs.; soaper's salts, 12 lbs.; waste soap-ashes, ½ bushel; silicious sand, ½ cwt.; glass-skimmings, 22 lbs.; broken green glass, 1 cwt. to 1¼ cwt.; basalt, 25 lbs. to ¼ cwt.

No. 2. PALE GREEN.—Pale sand, 100 lbs.; kelp, 35 lbs.; lixiviated wood ashes, 1½ cwt.; fresh, do., 40 lbs.; pipe-clay, ¾ cwt.; cullet, or broken glass, 1½ cwt.

No. 3. Yellow or white sand, 120 parts; woodashes, 80 parts; pearlashes, 20 parts; common salt, 15 parts; white arsenic, 1 part; very pale.

Crystal Glass.—No. 1. Refined pot-ashes, 60 lbs.; sand, 120 lbs.; chalk, 24 lbs.; nitre and white arsenic, of each 2 lbs.; oxide of manganese, 1 to 2 oz. No. 2. Pure white sand, 120 parts; refined ashes, 70 parts; saltpetre; 10 parts; white arsenic, ½ part; oxide of manganese, ½ part. No. 3. Sand, 120 parts; red lead, 50 parts; purified pearlash, 40 parts; nitre, 20 parts; manganese, ½ part.

Flask Glass (*of St. Etienne.*)—Pure silicious sand, 61 parts; potash, 3½ parts; lime, 21 parts; heavy spar, 2 parts; oxide of manganese, q. s.

Best German Crystal Glass.—Take 120 lbs. of calcined flints or white sand; best pearl-ashes, 70 lbs.; saltpetre, 10 lbs.; arsenic, ½ lb.; and 5 oz. manganese. No. 2. (CHEAPER.) Sand or flint, 120 lbs.; pearlash, 46 lbs.; nitre, 7 lbs.; arsenic, 6 lbs.; magnesia, 5 oz. This will require a long continuance in the furnace, as do all others when much of the arsenic is used.

Plate Glass.—No. 1. Pure sand, 40 parts; dry carbonate of soda, 26½ parts; lime, 4 parts; nitre, 1½ parts; broken plate glass, 25 parts. No. 2. URE'S.—Quartz-sand, 100 parts; calcined sulphate of soda, 24 parts; lime, 20 parts; cullet of soda-glass, 12 parts. No. 3. VIENNA.—Sand, 100 parts; calcined sulphate of soda, 50 parts; lime, 20 parts; charcoal, 2¾ parts. No. 4. FRENCH.—White quartz sand and cullet, of each 300 parts; dry carbonate of soda, 100 parts; slacked lime, 43 parts.

Crown Glass.—No. 1. Sand, 300 lbs.; soda-ash, 200 lbs.; lime, 30 to 35 lbs.; 200 to 300 lbs. of broken glass. No. 2. (BOHEMIAN.)—Pure silicious sand, 63 parts; potash, 22 parts; lime, 12 parts; oxide of manganese, 1 part. No. 3. (PROF. SCHWEIGER.) Pure sand, 100 lbs.; dry sulphate of soda, 50 parts; dry quicklime in powder, 17 to 20 parts; charcoal, 4 parts. PRODUCT—White and good.

Best Window Glass.—No. 1. Take of white sand, 60 lbs.; purified pearlashes, 30 lbs.; of saltpetre, 15 lbs.; of borax, 1 lb.; of arsenic, ½ lb. This will be very clear and colorless if the ingredients be good, and will not be very dear. No. 2. (CHEAPER.)—White sand, 60 lbs.; unpurified pearlashes, 25 lbs.; of common salt, 10 lbs.; nitre, 5 lbs.; arsenic, 2 lbs.; manganese, 1½ oz. No. 3. COMMON GREEN WINDOW-GLASS.—White sand, 60 lbs.; unpurified pearlashes, 30 lbs.; common salt, 10 lbs.; arsenic, 2 lbs.; manganese, 2 oz.

Looking Glass Plate.—No. 1. Cleansed white sand, 60 lbs.; pearlashes, purified, 25 lbs.; saltpetre, 15 lbs.; borax, 7 lbs. This composition should be continued long in the fire, which should be sometimes strong, and afterwards, more moderate, that the glass may be entirely free from bubbles before it be worked. No. 2. White sand, 60 lbs.; pearl-ashes, 20 lbs.; common salt, 10 lbs.; nitre, 7 lbs.; borax, 1 lb. This glass will run with as little heat as the former; but it will be more brittle, and refract the rays of light in a greater degree. No. 3. Washed white sand, 60 lbs.; purified pearl-ashes, 25 lbs.; nitre, 15 lbs.; borax, 7 lbs. If properly managed, this glass will be colorless.

Window Glass.—No. 1. Dried sulphate of soda, 11 lbs.; soaper-salt, 10 lbs.; lixiviated soap-waste, ½ bush.; sand, 50 to 60 lbs.; glass-pot skimmings, 22 lbs.; broken *pale* green glass, 1 cwt. No. 2. (PALER).—White sand, 60 lbs.; pearlashes, 30 lbs.; common salt, 10 lbs.; arsenic, 10 lbs.; oxide of manganese, 2 to 4 oz.

No. 3. (VERY PALE.)—White sand, 60 lbs.; good potashes, 25 lbs.; common salt, 10 lbs.; nitre, 5 lbs.; arsenic, 2 lbs.; manganese; 2 to 4 oz. as required; broken *pale* window-glass, 14 lbs.

Magic Paper. — Take lard oil, or sweet oil, mixed to the consistencey of cream, with either of the following paints, the color of which is desired: Prussian blue, lamp-black, Venetian red, or chrome green, either of which should be rubbed with a knife on a plate or stone until smooth. Use rather thin but firm paper; put on with a sponge, and wipe off as dry as convenient; then lay them between uncolored paper, or between newspapers, and press by laying books or some other flat substance upon them until the surplus oil is absorbed, when it is ready for use.

To Make Grindstones from Common Sand.—River sand, 30 lbs.; shellac, 10 parts; powdered glass, 2 parts; melt in an iron pot, and cast into moulds.

Printing Rollers are made of glue and molasses, with sometimes a little Spanish white. The proportions are 1 lb. glue to 1 pint molasses. Break the glue to pieces, soak for 24 hours is sufficient, then melt with the molasses, and cast in a mould previously oiled to prevent it from sticking. When it gets hard after long use remelt it, using a little more molasses.

Savage's Printing Ink.—Pure balsam of copaiba, 9 oz.; lampblack, 3 oz.; indigo and Prussian blue, each 5 drachms; Indian red, ¾ oz.; yellow soap, 3 oz. Miz, and grind to the utmost smoothness.

Holes in Millstones are filled with melted alum, mixing burr sand with it. If the hole is large, put some pieces of burr-mill stones in it first, and pour in melted alum. These pieces of block should be cut exactly to fit. There should be small joints, and fastened with plaster of Paris. These holes should be cut at least 4 inches deep; there is then no danger of their getting loose.

Fitting a New Back in an Old Millstone.—Block your stone up with a block of wood, having its face down until it lies even, solid, and perfectly level; then pick and scrape off all the old plaster down to the face blocks, so that none remains but what is in the joints of the face blocks; then wash these blocks, and keep them soaked with water. Keep a number of pieces of burr blocks, at the same time, soaked with water. Take a pail half filled with clean water, and mixed with 2 tablespoonfuls of glue water, boiled and dissolved; mix in with your hand plaster of Paris until it be thick enough that it will not run; and, breaking all the lumps, pour this on the stone, rubbing it in with your hand; the stone being at the same time damped; and place small pieces of stone all over the joints of the face blocks; you then, with more plaster, mixed in the same way, but more stiff, with this and pieces of burr stones, build walls round the eye and verge 4 or 5 inches high, leaving the surface uneven and the eye larger, as it will be brought to its proper size by the last operation. It is better to build up the wall of the running stone round the verge for 3 inches without any spalls, so that the holes may be cut in to balance it. If you wish to make your stone heavier, you will take small pieces of iron, perfectly clean and free from grease, and lay them evenly all around the stone in the hollow place between the two walls just built; and with plaster mixed a little thicker than milk, pour in under and through all the crevices in the iron until the surface is nearly level with the two walls. If the stones do not require additional weight added, instead of iron use pieces of stone the same way, leaving the surface rough and uneven. Again, as before, build walls round the verge of the stone, and round the eye of the stone, until they are within 2 inches of the thickness you want your stones to be, the wall round the eye being 2 inches higher than that round the verge, and filling the space between the walls with stones; and, pouring in plaster again, make it nearly level with the walls, but leaving the surface rough and jagged, to make the plaster adhere well to it. Let it stand until the back is dry and perfectly set, when you raise the stone upon its edge, and, with a trowel, plaster round the edge of the stone neatly, giving it a taper of ½ inch from the face to the back of the stone. When cased round in this way, lay the stone down on the cock-head; it being in the balance ryne, but the driver off, then raise the spindle, and balance the stone as already directed before putting on the remainder of the back. Then have a tin made the size of the eye, and to reach from the balance ryne to the thickness you want the stone to be at the eye. This tin should be exactiy fitted to its place, and made fast; then fit a hoop of wood or iron round the verge, having the upper edge of the thickness from the face you want the stone to be at the verge, and equal all round. This hoop should be greased; and all the cracks round it, and the tin in the eye, being stopped, you pour thin plaster (with more glue water then in previous operations, to prevent it from setting so quickly, and to give time to finish off the back correctly) until it be level with the hoop round the verge, and with a straight edge, one end resting on the hoop, and the other end resting on the tin at the eye; then, by moving it round, and working the plaster with a trowel, make the surface of the back even and smooth between these two points. The hoop is then taken off, and the back and edges planed smooth; then lower the spindle until your runner lies solid, and put your band or hoop on, it being first made nearly red hot, and taking care that it is of sufficient size not to require too much driving; if fitting too tightly, it may loosen the back in driving it to its proper place. It may be cooled gently by pouring water on it; and, when cool, it should fit tight.

Mill Dams.—When building a dam, you should select the most suitable place. If you can, place it across the stream near a rocky bluff, so that the ends of the dam may run into the bluff. This will prevent the water running by at the ends of the dam. Build your dam strong; if this is not done, they are breaking up often, causing ruinous expense in money and loss of time.

Rock Dams are incomparably the best in use, if there is plenty of material at hand for building, and a rock bottom to the stream; if there is not a rock bottom, you should dig a trench in the bottom, deep enough, so that the water cannot undermine it. This should be the same as if you were building the foundation of a large building. The wall to be built should be of a small, circular form, so that the back of the circle should be next to the body of water, which may by its pressure tighten it. To secure the water from leaking through at the ends of the dam, dig a ditch deeper than the bottom of the river; then fill this with small pieces of rock, and pour in cement. This cement is made of hydraulic cement, and is made of one part cement to five parts of pure sand. It will effectually stop all crevices. A rock dam, if well built, will be perfectly tight. Use as large rock as you conveniently can move; building this wall 4 to 6 feet thick, according to the length of the dam, with jam or buttresses every place where they are needed to strengthen it. Make true joints to these rocks, especially on the ends, so that they may join close together. When you have the outside walls laid in cement, for every layer fill the middle up with pieces of small rock, pouring in your grout, so that there may not be a crevice but what is filled. If there is any crevice or hole left open, the water will break through, wearing it larger and larger. If the stream is wide and large, it is necessary to build the dam in two sections, which should be divided by a waste way, necessary for the waste or surplus water to run over, to keep the head in its proper place or height. Let each section, next to where the water is to be run over, be abutments, built to strengthen the dam. The last layer of rock, on the top where the waste water runs over, should project 5 or 6 inches over the back of the dam, so that the water may not undermine it. This last layer should be of large rocks, and jointed true; then laid in hydraulic cement, in proportion of 1 of cement to 3 of sand. When the dam is built, the front should be filled up with coarse gravel or clay; this is best done with teams, as the more it is tramped the more durable it becomes.

Frame Dams.—In building a frame dam commence with a good foundation, laying the first sills in the bottom, of sufficient depth. They should be large square timbers that will last in the water without rotting. Where there is a soft foundation, the bottom should first be made level; then dig trenches for the mud sills, about 7 or 8 feet apart, lengthways of the stream, and 10 or 12 feet long. Into these first sills other sills must be framed, and put crosswise of the stream, 6 or 8 feet apart, to reach as far across the stream as necessary. Then two outside sills should be piled down with 2-inch plank driven down to a depth of 4 or 5 feet. If this can be done conveniently, they are to be jointed as closely as possible. It would be better to line with some stuff 1 inch thick; then with posts their proper length, about 12 or 14 inches square, which should be framed into the uppermost sills, in both sides, and all the way across the dam, from bank to bank, at a distance of 6 feet apart. Then, with braces to each post, to extend two-thirds of the length of the post, where they should be joined together with a lock, instead of a mortise and tenon, with an iron bolt of 1 or 1¼ inches in diameter, going through both, and tightened with a screw and nut. When mortises and tenons are used, they often become rotten and useless in a few days. These braces should be set at an angle of 50 or 60° with the other end mortised into the mud sill. These braces require to be about 6 to 8 inches, and as long as you find necessary; being covered with dirt, it will not decay for a long time, as the air is excluded. These posts should be capped from one to the other, plate fashion. The posts should be lined with 2 or 2½ inch plank on the inside, pinned to the plank, and should, in the middle, be filled in with dirt.

If the stream is large and wide, the dam should be built in two sections, which should be divided by a waste-way for the surplus water, which should be in the centre of the dam, and sufficient for all the waste-water to run over. Let each section of the dam form an abutment next to the waste-way, placing cells or sills 4 feet apart the length of the waste-way; in each of these sills, posts should be framed with a brace for the sides. These rows of posts, standing across the dam, will form the sectional abutments; the middle one may be constructed by being lengthways of the stream, with shore braces, so that they will not be in the way of driftwood passing down the stream; it being necessary for strong pieces for a bridge. Then cover the sills with an apron of 2-inch plank joined perfectly straight, to extend 30 or 40 feet below the dam, to prevent the undermining of the dam. The planks which are used for the purpose of lining the posts which form the abutments of each section of the dam and the ends of the waste-way, should be truly pointed, so as to prevent any leakage. The dam being built, the dirt should be filled in with teams; as the more it is tramped the better. Clay or coarse gravel is the best. Then place your gates on the upper side of the waste-way, the size that is necessary to a level with low-water mark; which gates are not to be raised except in times of high water, as the proper height of the mill-pond should be regulated by boards placed over the gate for the desired head, as the water should be allowed to pass at all times freely over them. To strengthen the dam, if you think necessary, 2-inch plank may be used in lining the front side of the dam, long enough to reach from the bottom of the stream (on an inclined plane, and next to the body of water) to the top of the dam, and filled up nearly to the top of the dam with clay or gravel well tramped down.

Brush or Log Dams are very often used in small, muddy streams. When the bottom of the stream is of a soft nature; take a flat-boat where you want to fix your dam, and drive piles the whole length of the stream, about 3 or 4 feet apart, as deep as you can. Take young oak saplings, pointed at the end, for the purpose. If you can, construct a regular pile-driver, similar to those in use for making trestle-work on the railways. The weight may be pulled up by horses instead of an engine. When you have finished driving piles, make some boxes or troughs of 2 or 3 inch plank, about 3 feet wide and as long as the plank is. Sink these in the water, the length of the dam, close to the piles, by loading them with rock, until they are at the bottom of the stream, filling in the front part of the dam with dirt and brush, nearly to the height you want it. This kind of dam will last a long time.

Whenever there is a small break in the dam or race, cut up some willows and brush, put them in the break along with some straw and dirt, and ram them down with clay.

In regard to the flume, the greatest care must be taken to insure strength and durability, combined with lightness. Every step taken in its construction must be of such a nature as to unite these qualities in the highest possible degree, otherwise the whole is, in a manner, labor lost.

To Restore Burnt Steel, and Weld Cast Steel.—Borax, 48 oz.; sal ammonic, 16 oz.; prussiate potash, 8 oz.; rosin, 4 oz.; alcohol, ½ gill; soft water, ½ pint. Put into an iron pan, and hold over a slow fire till it comes to a slow boil, and until the liquid matter evaporates, not letting it boil hard, and being careful to stir it well from the bottom all the time.

Steel may be burned till it drops apart, and the particles gathered and welded together with this composition, making it as durable as ever.

Superior Bell Metal.—Copper, 100 lbs.; tin, 23 lbs.

Electrum.—Copper, 8 nickel, 4 zinc, 3½ parts. This compound is unsurpassed for ease of workmanship and beauty of appearance.

To Write in Silver.—Mix 1 oz. of the finest pewter or block tin, and 2 oz. of quicksilver together till both become fluid, then grind it with gum water, and write with it. The writing will then look as if done with silver.

Best Bronze for Brass.—Take 1 lb. muriatic acid, and ½ lb. white arsenic. Put them into an earthen vessel, and then proceed in the usual manner.

Another Bronze for Brass.—One ounce muriate of ammonia, ½ oz. alum, ¼ oz. arsenic, dissolved all together in 1 pint of strong vinegar.

Zincing.—Copper and brass vessels may be covered with a firmly adherent layer of pure zinc by boiling them in contact with a solution of chloride of zinc, pure zinc turnings being at the same time present in considerable excess.

Dentist's Emery Wheels.—Emery, 4 lbs.; shellac, ½ lb.; melt the shellac over a slow fire; stir in the emery, and pour it into a mould of plaster of Paris. When cold it is ready for use.

Incrustation of Boilers.—(DELFOSSE'S PATENT).—If the boiler be stationary, and fed with fresh water, the amount of anti-petrifying mixture per horse power for 336 hours' consumption may be made by mixing together 12 oz. muriate of soda, 2 drs. of dry tannic or gallic acid, 2½ oz. of hydrate of soda, or 1 or ½ oz. of subcarbonate of potash. For locomotive boilers travelling an average of 140 miles per day, the quantity of the mixture per horse power is increased one-fifth. If the water be brackish, or a mixture of salt and fresh, the muriate of soda is omitted, and instead of 12 oz., are used for 2½ oz. of hydrate of soda, and 5 drs. instead of 2 of the dry tannic or gallic extract. The mixture is also prepared in this manner when sea water is used in the boiler. The patentee prefers introducing the mixture into stationary boilers in quantities for two, three, or more days, but locomotive and marine boilers are to be supplied daily with a portion of the mixture, corresponding with the amount of duty to be performed.

To Lessen Friction in Machinery.—Grind together black lead with 4 times its weight of lard or tallow. Camphor is sometimes added (7 lbs. to the hundred weight.)

Colored Glass.—(FINE BLUE).—To 10 lbs. flint glass, previously melted and cast into water, add zaffer, 6 drs., ½ oz. of calcined copper, prepared by putting sheet copper into a crucible, and exposing it to the action of a fire not strong enough to melt the copper, and you will have the copper in scales, which you pound.

BRIGHT PURPLE.—Use 10 lbs. flint glass as before; zaffer, 5 drs.; precipitate of calcium, 1 dr.

GOLD YELLOW.—Twenty-eight pounds flint glass, and a quarter pound of the tartar which is found in urine, purify by putting it in a crucible in the fire till it smoke no more; add 2 oz. of manganese.

To Take a Plaster of Paris Cast from a Person's Face.—The person must lie on his back, and his hair be tied behind, into each nostril put a conical piece of paper open at each end to allow of breathing. The face is to be lightly oiled over, and the plaster, being properly prepared, it is to be poured over the face, taking particular care that the eyes are shut, till it is a quarter of an inch thick. In a few minutes the plaster may be removed. In this a mold is to be formed, from which a second cast is to be taken, that will furnish casts exactly like the original.

To Harden and Temper Cast Steel.—For saws and springs in general, the following is an excellent liquid: Spermaceti oil, 20 gals.; beef suet *rendered*, 20 lbs.; neat's-foot oil, 1 gallon; pitch, 1 lb.; black resin, 3 lbs. The last two articles must be previously melted together, and then added to the other ingredients, when the whole must be heated in a proper iron vessel, with a close cover fitted to it, until all moisture is evaporated, and the composition will take fire on a flaming body being presented to its surface.

Furniture Oil.—Linseed oil, 1 gallon; alkanet root, 3 oz.; rose pink, 1 oz. Boil them together ten minutes, and strain so that the oil be quite clear.

To Cast Figures in Imitation of Ivory.—Make isinglass and brandy into a paste, with powdered egg-shells very finely ground. You may give it what color you choose; but cast it warm into your mould which you previously oil over; leave the figure in the mould till dry, and you will find on taking it out that it bears a very strong resemblance to ivory.

To Print a Picture from the Print Itself.—The page or picture is soaked in a solution, first of potassa, and then of tartaric acid. This produces a perfect diffusion of crystals of bitartrate of potassa through the texture of the unprinted part of the paper. As this salt resists oil, the ink roller may now be passed over the surface, without transferring any part of its contents except to the printed part.

To Clean Old Oil-paintings.—Dissolve a small quantity of salt in stale urine; dip a woolen cloth in the mixture, and rub the paintings over with it till they are clean; then wash them with a sponge and clean water; dry them gradually, and rub them over with a clean cloth. Should the dirt be not easily removed by the above preparation, add a small quantity of soft soap. Be very careful not to rub the paintings too hard.

To Renew Old Oil-paintings.—The blackened lights of old pictures may be instantly restored to their original hue by touching them with deutoxide of hydrogen diluted with six or eight times its weight of water. The part must be afterwards washed with a clean sponge and water.

To Lengthen Levers of Anchor-escapement Watches without Hammering or Soldering.—Cut square across with a screw-head file, a little back from the point above the fork, and, when you have thus cut into it to a sufficient depth, bend forward the desired distance the piece thus partially detached. In the event of the piece snapping off while bending—which, however, rarely happens—file down the point level with the fork, and insert a pin, English lever style.

Chain Dip Solution, for Brass Chains, &c.—Sulphuric acid, 2¼ oz; nitric acid, 2 oz.; rain-water, 2 oz.; saltpetre, 1 dr.; mix together in a glass bottle, and let stand a few hours. Apply by dipping the article into the solution quickly, and then at once wash off thoroughly, and rinse in clean rain-water and dry in saw-dust. Removes instantaneously all stains or discolorations, and gives to the article a perfectly bright appearance.

Pickle for Frosting and Whitening Silver Goods.—Sulphuric acid, 1 dr.; water, 4 oz.; heat the pickle, and immerse the silver in until frosted as desired; then wash off clean, and dry with a soft linen cloth, or in fine clean saw-dust. For whitening only, a smaller proportion of acid may be used.

Etruscan Gold Coloring.—Alum, 1 oz.; fine table-salt, 1 oz.; saltpetre (powdered,) 2 oz.; hot rain-water, sufficient to make the solution, when dissolved, about the consistency of thick ale; then add sufficient muriatic acid to produce the color desired. The degree of success must always depend, in a greater or less degree, upon the skill or judgment of the operator. The article to be colored should be from fourteen to eighteen carats fine, of pure gold and copper only, and be free from coatings of tin or silver solder. The solution is best used warm, and when freshly made the principle on which it acts is to eat out the copper alloy from the surface of the article, leaving thereon pure, frosted gold only. After coloring, wash off, first in rain-water, then in alcohol, and dry without rubbing, in fine, clean saw-dust. Fine Etruscan jewelry that has been defaced or tarnished by use may be perfectly renewed by the same process.

Tarnish on Electro-plated Ware may be removed by immersing the article from one to ten or fifteen minutes, or until the tarnish has been removed, but no longer, in the following solution: Rain-water, 2 gals.; cyanuret potassa, ½ lb.; dissolve, and put into a stone jug or jar and closely cork. After immersion, the articles must be taken out and thoroughly rinsed in two or three waters, then dried with a soft linen cloth, or, if frosted or chased work, with fine, clean saw-dust. Tarnished jewelry may be speedily restored by this process; but make sure work of removing the alkali, otherwise it will corrode the goods.

A Bright Gold Tinge may be given to silver by steeping it for a suitable length of time in a weak solution of sulphuric acid and water strongly impregnated with iron-rust.

To Make a Diamond Mill.—Make a brass chuck or wheel, suitable for use on a foot-lathe, with a flat, even surface or face of about 1½ or 2 inches in diameter; then place a number of the coarsest pieces of your diamond-dust on different parts of its face, and with a smooth-faced steel hammer drive the pieces of dust all evenly into the brass to nearly or quite level with the surface. Your mill, thus prepared, is now used for making pallet jewels or for grinding stone and glass of any kind. For polishing, use a bone or boxwood chuck or wheel, of similar form to your mill, and coat it lightly with the finest grade of your diamond-dust and oil; with this a beautiful polish may be given to the hardest stone.

To Temper Case and other Springs of Watches.—Draw the temper from the spring, and fit it properly in its place in the watch; then take it out and temper it hard in rain-water (the addition of a little table-salt to the water will be an improvement;) after which place it in a small sheet-iron ladle or cup and barely cover it with linseed oil; then hold he ladle over a lighted lamp until the oil ignites; let it burn until the oil is nearly, not quite all, consumed; then re-cover with oil and burn down as before; and so a third time; at the end of which, plunge it again into water. Main and hair springs may, in like manner, be tempered by the same process: first draw the temper, and properly coil and clamp to keep in position, and then proceed the same as with case springs.

To Make Red Watch Hands.——1 oz. carmine, 1oz. muriate of silver, ½ oz. tinner's japan; mix together in an earthen vessel, and hold over a spirit-lamp until formed into a paste. Apply this to the watch hand, and then lay it on a copper plate, face side up, and heat the plate sufficiently to produce the color desired.

To Drill into Hard Steel.—Make your drill oval in form, instead of the usual pointed shape, and temper as hard as it will bear without breaking; then roughen the surface where you desire to drill with a little diluted muriatic acid, and, instead of oil, use turpentine or kerosene, in which a little gum camphor has been dissolved, with your drill. In operating, keep the pressure on your drill firm and steady; and if the bottom of the hole should chance to become burnished, so that the drill will not act, as sometimes happens, again roughen with diluted acid as before; then clean out the hole carefully, and proceed again.

To Case-harden Iron.—If you desire to harden to any considerable depth, put the article into a crucible with cyanide of potash, cover over and heat altogether, then plunge into water. This process will harden perfectly to the depth of two or three inches.

To Put Teeth in a Watch or Clock Wheels without Dovetailing or Soldering.—Drill a hole somewhat wider than the tooth square through the plate, a little below the base of the tooth; cut from the edge of the wheel square down to the hole already drilled; then flatten a piece of wire so as to fit snugly into the cut of the saw, and with a light hammer form a head on it like the head of a pin. When thus prepared, press the wire or pin into position in the wheel, the head filling the hole drilled through the plate, and the end projecting out so as to form the tooth; then with a sharp pointed graver cut a small groove each side of the pin from the edge of the wheel down to the hole, and with a blow of your hammer spread the face of the pin so as to fill the grooves just cut. Repeat the same operation on the other side of the wheel, and finish off in the usual way. The tooth will be found perfectly riveted in on every side, and as strong as the original one, while in appearance it will be equal to the best dovetailing.

To Tighten a Cannon Pinion on the Centre Arbor when too Loose.—Grasp the arbor lightly with a pair of cutting nippers, and, by a single turn of the nippers around the arbor, cut or raise a small thread thereon.

Jeweller's Alloys.—EIGHTEEN CARAT GOLD FOR RINGS.—Gold coin, 19½ grs.; pure copper, 3 grs.; pure silver, 1½ grs.

CHEAP GOLD, TWELVE CARAT.—Gold coin, 25 grs.; pure copper, 13½ grs.; pure silver, 7⅓ grs.

VERY CHEAP FOUR CARAT GOLD.—Copper, 18 parts; gold, 4 parts; silver, 2 parts.

IMITATIONS OF GOLD.—1. Platina, 4 dwt.; pure copper, 2¼ dwt.; sheet-zinc, 1 dwt.; block-tin, 1¾ dwt.; pure lead, 1½ dwt. If this should be found too hard or brittle for practical use, re-melting the composition with a little sal-ammoniac will generally render it malleable as desired. 2. Platina, 2 parts; silver, 1 part; copper, 3 parts. These compositions, when properly prepared, so nearly resemble pure gold that it is very difficult to distinguish them therefrom. A little powdered charcoal mixed with metals while melting will be found of service.

BEST OROIDE OF GOLD.—Pure copper, 4 oz.; sheet zinc, 1¾ oz.; magnesia, ⅝ oz.; sal-ammoniac, ½ oz.; quicklime, 9-32 oz.; cream tartar, ⅞ oz. First melt the copper at as low a temperature as it will melt; then add the zinc, and afterwards the other articles, in powder, in the order named. Use a charcoal fire to melt these metals.

Bushing Alloy for Pivot Holes, &c.—Gold coin, 3 dwt.; silver, 1 dwt., 20 grs.; copper, 3 dwt., 20 grs.; palladium, 1 dwt. The best composition known for the purpose named.

Gold Solder for Fourteen to Sixteen-Carat Work.—Gold coin, 1 dwt.; pure silver, 9 grs.; pure copper, 6 grs.; brass, 3 grs.

DARKER SOLDER.—Gold coin, 1 dwt.; pure copper, 8 grs.; pure silver, 5 grs.; brass, 2 grs.; melt together in charcoal fire.

The Northern-Light Burning Fluid.—COSTS ABOUT EIGHT CENTS PER GALLON.—Get good deodorized benzine, 60 to 65 gravity, and to each barrel of 42 gals. add 2 lbs. pulverized alum, 3½ oz. gum camphor, and 3½ oz. oil of sassafras, or 2 oz. oil bergamot; stir up and mix thoroughly together and it will soon be ready for use.

N. B.—As this fluid creates a much larger volume of light and flame than carbon oil, it is necessary to use either a high burner, such as the Sun burner, to elevate the flame away from the lamp, in order to keep it cool, or, instead thereof, to use a burner provided with a tube for the escape of the gas generated from the fluid, such, for instance, as the Meridian burner.

To Reduce Oxide of Zinc.—The oxide may be put in quantities of 500 or 600 lbs. weight into a large pot over the fire; pour a sufficient quantity of muriatic acid over the top, to act as a flux, and the action of the fire will melt the dross, when the pure metal will be found at the bottom of the pot.

New Process to Restore Burnt Steel.—When your steel is burnt, immerse it immediately, for a very short time, in cold water; then hammer it on the anvil, turning, moving, and otherwise manipulating it while undergoing this treatment. A little dexterous practice will soon enable you to restore steel, by this beautiful and simple process, that would otherwise be hopelessly ruined.

To Remove Rust from Iron or Steel.—For cleaning purposes, &c., kerosene oil or benzine are probably the best things known. When articles have become pitted by rust, however, these can, of course, only be removed by mechanical means, such as scouring with fine powder, or flour of emery and oil, or with very fine emery paper. To prevent steel from rusting, rub it with a mixture of lime and oil, or with mercurial ointment, either of which will be found valuable.

To Restore Frozen Silver Solution.—If it is the whitening solution, add 10 pennyweights of cyanide of potassium to a pint of the solution. For the first, or hard coat solution, add about double the above quantity.

On Watch Cleaning.—It is hardly necessary to say that great caution must be observed in taking the watch down—that is, in separating its parts. If you are new at the business think before you act, and then act slowly. Take off the hands carefully so as not to bend the slender pivots upon which they work; this will be the first step. 2. Loosen and lift the movement from the case. 3. Remove the dial and dial wheels. 4. Let down the main-spring by placing your bench key upon the arbor, or "winding post," and turning as though you were going to wind the watch until the click rests lightly upon the ratchet; then with your screw-driver press the point of the click away from the teeth, and ease down the springs. 5. Draw the screws (or pins) and remove the bridges of the train, or the upper plate, as the case may be. 6. Take out the balance. Great care must be observed in this or you will injure the hair-spring. The stud or little square post into which the hair-spring is fastened may be removed from the bridge or plate of most modern watches, without unkeying the spring, by slipping a thin instrument, as the edge of a knife blade, under the corner of it and prying upward. This will save you a considerable amount of trouble, as you will not have the hair-spring to adjust when you reset the balance.

If the watch upon which you propose to work has an upper plate, as an American or an English lever, for instance, loosen the lever before you have entirely separated the plates, otherwise it will hang and most likely be broken.

Having the machine now down, brush the dust from its different parts and subject them to a careful examination with your eye-glass. Assure yourself that the teeth of the wheels and leaves of the pinions are all perfect and smooth; that the pivots are all straight, round and highly polished, that the holes through which they are to work are not too large, and have not become oval in shape; that every jewel is smooth and perfectly sound; and that none of them are loose in their settings. See, also, that the escapement is not too deep or too shallow; that the lever or cylinder is perfect; that all the wheels have sufficient play to avoid friction, but not enough to derange their coming together properly; that none of them work against the pillar-plate; that the balance turns horizontally and does not rub; that the hair-spring is not bent or wrongly set so that the coils rub on each other, on the plate, or on the balance; in short, that everything about the whole movement is just as reason would teach you it should be. If you find it otherwise, proceed to repair in accordance with a carefully weighed judgment, and the processes given in the next chapter, after which clean--if not the watch only needs to be cleaned, and therefore you may go ahead with your work at once.

TO CLEAN.—Many watchmakers wet the pillar-plates and bridges with saliva, and then dipping the brush into pulverized chalk or Spanish whiting, rub vigorously until they appear bright. This is not a good plan, as it tends to remove the plating and roughen the parts, and the chalk gets into the holes and damages them, or sticks around the edges of the wheel-beds. The best process is to simply blow your breath upon the plate or bridge to be cleaned, and then to use your brush with a little prepared chalk—(See recipe for preparing it.) The wheels and bridges should be held between the thumb and finger in a piece of soft paper while undergoing the process; otherwise the oil from the skln will prevent their becoming clean. The pinions may be cleaned by sinking them several times into a piece of pith, and the holes by turning a nicely shaped piece of pivot wood into them, first dry and afterwards oiled a very little with watch oil. When the holes pass through jewels you must work gently to avoid breaking them.

The oiling above named is all the watch will need. A great fault with many watchmakers lies in their use of too much oil.

THE CHEMICAL PROCESS.—Some watchmakers employ what they call the "Chemical Process" to clean and remove discolorations from watch movements. It is as follows:

Remove the screws and other steel parts; then dampen with a solution of oxalic acid and water. Let it remain a few moments, after which immerse in a solution made of one-fourth pound cyanuret potassa to one gallon rain water. Let remain about five minutes, and then rinse well with clean water, after which you may dry in sawdust, or with a brush and prepared chalk, as suits your convenience. This gives the work an excellent appearance.

To Prepare Chalk for Cleaning.—Pulverize your chalk thoroughly, and then mix it with clear rain water in the proportion of two pounds to the gallon. Stir well and then let stand about two minutes. In this time the gritty matter will have settled to the bottom. Pour the water into another vessel, slowly so as not to stir up the settlings. Let stand until entirely settled, and then pour off as before. The settlings in the second vessel will be your prepared chalk, ready for use as soon as dried.

Spanish whiting treated in the same way makes a very good cleaning or polishing powder. Some operatives add a little jeweler's rouge, and we think it an improvement; it gives the powder a nice color at least, and therefore adds to its importance in the eyes of the uninitiated. In cases where a sharper polishing powder is required, it may be prepared in the same way from rotten stone.

Pivot Wood.—Watchmakers usually buy this article of watch-material dealers. A small shrub known as Indian arrow-wood, to be met with in the Northern and Western States, makes an excellent pivot wood. It must be cut when the sap is down, and split into quarters so as to throw the pith outside of the rod.

Pith for Cleaning.—The stalk of the common mullen affords the best pith for cleaning pinions. Winter, when the stalk is dry, is the time to gather it. Some use cork instead of pith, but it is inferior.

To Pivot.—When you find a pivot broken, you will hardly be at a loss to understand that the easiest mode of repairing the damage is to drill into the end of the pinion or staff, as the case may be, and having inserted a new pivot, turn it down to the proper proportions. This is by no means a difficult thing when the piece to be drilled is not too hard, or when the temper may be slightly drawn without injury to the other parts of the article.

To Tell when the Lever is of Proper Length.—You may readily learn whether or not a lever is of proper length, by measuring from the guard point to the pallet staff, and then comparing with the roller or ruby-pin table; the diameter of the table should always be just half the length measured on the lever. The rule will work both ways, and may be useful in cases when a new ruby-pin table has to be supplied.

To Change Depth of Lever Escapement.—If you are operating on a fine watch the best plan is to put a new staff into the lever, cutting its pivots a little to one side—just as far as you desire to change the escapement. Common watches will not, of course, justify so much trouble. The usual process in their case is to knock out the staff, and with a small file cut the hole oblong in a direction opposite to that in which you desire to move your pallets; then replace the staff, wedge it to the required position, and secure by soft soldering.

In instances where the staff is put in with a screw you will have to proceed differently. Take out the staff, pry the pallets from the lever, file the pin holes to slant in the direction you would move the pallets, without changing their size on the other side of the lever. Connect the pieces as they were before, and with the lever resting on some solid substance you may strike lightly with your hammer until the bending of the pins will allow the pallets to pass into position.

To Tell when the Lever Pallets are of Proper Size.—The clear space between the pallets should correspond with the outside measure, on the points, of three teeth of the scape wheel. The usual mode of measuring for new pallets is to set the wheel as close as possible to free itself when in motion. You can arrange it in your depthing tool, after which a measurement between the pivot holes of the two pieces, on the pillar plate, will show you exactly what is required.

To Put Watches in Beat.—If a cylinder escapement, or a detached lever, put the balance into a position; then turn the regulator so that it will point directly to the pivot-hole of the pallet staff, if a lever, or of the scape-wheel, if a cylinder. Then lift out the balance with its bridge or clock, turn it over and set the ruby-pin directly in the line with the regulator, or the square cut of the cylinder at right angles with it. Your watch will then be in perfect beat.

In case of an American or an English lever, when the regulator is placed upon the plate, you will have to proceed differently. Fix the balance into its place, cut off the connection of the train, if the mainspring is not entirely down, by slipping a fine broach into one of the wheels, look between the plates and ascertain how the lever stands. If the end furthest from the balance is equi-distant between the two brass pins it is all right—if not, change the hairspring till it becomes so.

If dealing with a duplex watch, you must see that the roller notch, when the balance is at rest is exactly between the locking tooth and the line of centre—that is, a line drawn from the centre of the roller to the centre of the scape-wheel. The balance must start from its rest and move through an arc of about ten degrees before bringing the locking tooth into action.

To Prevent a Chain Running off the Fusee.—In the first place you must look after and ascertain the cause of the difficulty. If it results from the chain's being too large, the only difficulty is a new chain. If it is not too large, and yet runs off without any apparent cause, change it end for end—that will generally make it go all right. In cases where the channel in the fusee has been damaged and is rough, you will be under the necessity of dressing it over with a file the proper size and shape. Sometimes you find the chain naturally inclined to work away from the body of the fusee. The best way to remedy a difficulty of this kind is to file off a very little from the outer lower edge of the chain the entire length—this, as you can see, will incline it to work on instead of off. Some workmen, when they have a bad case, and a common watch, change the standing of the fusee so as to cause the winding end of its arbor to incline a little from the barrel. This, of course, cannot do otherwise than make the chain run to its place.

To Weaken the Hair-Spring.—This is often effected by grinding the spring down. You remove the spring from the coilet, and place it upon a piece of pivot wood cut to fit the centre coil. A piece of soft steel wire, flattened so as to pass freely between the coils, and armed with a little pulverized oil stone and oil, will serve as your grinder, and with it you may soon reduce the strength of the spring. Your operations will, of course, be confined to the centre coil, for no other part of the spring will rest sufficiently against the wood to enable you to grind it, but this will generally suffice. The effect will be more rapid than one would suppose, therefore it will stand you in hand to be careful or you may get the spring too weak before you suspect it.

To Tighten a Ruby Pin.—Set the ruby pin in asphaltum varnish. It will become hard in a few minutes, and be much firmer and better than gum shellac, as generally used.

To Temper Brass or to Draw its Temper.—Brass is rendered hard by hammering or rolling, therefore when you make a thing of brass, necessary to be in temper, you must prepare the material before shaping the article. Temper may be drawn from brass by heating it to a cherry red, and then simply plunging it into water the same as though you were going to temper steel.

To Temper Drills.—Select none but the finest and best steel for your drills. In making them never heat higher than a cherry red, and always hammer till nearly cold. Do all your hammering in one way, for if, after you have flattened your piece out, you attempt to hammer it back to a square or a round you spoil it. When your drill is in proper shape heat it to a cherry red, and thrust it into a piece of resin, or into quicksilver.

Some use a solution of cyanuret potassa and rain water for tempering their drills, but for my part I have always found the resin or quicksilver to work best.

To Temper Gravers.—Gravers and other instruments larger than drills, may be tempered in quicksilver as above; or you may use lead instead of quicksilver. Cut down into the lead, say half an inch; then, having heated your instrument to a light cherry red, press it firmly into the cut. The lead will melt around it, and an excellent temper will be imparted.

Other Methods to Temper Case Springs.—Having fitted the spring into the case according to your liking, temper it hard by heating and plunging into water. Next polish the small end so that you may be able to see when the color changes; lay it on a piece of copper or brass plate, and hold the plate over your lamp, with the blaze directly under the largest part of the spring. Watch the polished part of the steel closely, and when you see it turn blue remove the plate from the lamp, letting all cool gradually together. When cool enough to handle polish the end of the spring again, place it on the plate and hold it over the lamp as before. The third blueing of the polished end will leave the spring in proper temper. Any steel article to which you desire to give a spring temper may be treated in the same way.

Another process said to be good, is to temper the spring as in the first instance; then put it in a small iron ladle, cover it with linseed oil and hold over a lamp till the oil takes fire. Remove the ladle, but let the oil continue to burn until nearly all consumed, when blow out, re-cover with oil and hold over the lamp as before. The third burning out of the oil will leave the spring in the right temper.

To Temper Clicks, Ratchets, &c.—Clicks, Ratchets, or other steel articles requiring a similar degree of hardness should be tempered in mercurial ointment. The process consists in simply heating to a cherry red and plunging into the ointment. No other mode will combine toughness and hardness to such an extent.

To Draw the Temper from Delicate Steel Pieces without Springing them.—Place the article from which you desire to draw the temper into a common iron clock key. Fill around it with brass or iron filings, and then plug up the open end with a steel, iron or brass plug, made to fit closely. Take the handle of the key with your plyers and hold its pipe into the blaze of a lamp till near hot, then let it cool gradually. When sufficiently cold to handle, remove the plug, and you will find the article with its temper fully drawn, but in all other respects just as it was before.

You will understand the reason for having the article thus plugged up while passing it through the heating and cooling process, when we tell you that springing always results from the action of changeable currents of atmosphere. The temper may be drawn from cylinders, staffs, pinions, or any other delicate pieces by this mode with perfect safety.

To Temper Staffs, Cylinders or Pinions, without Springing them.—Prepare the articles as in the preceding process, using a steel plug. Having heated the key-pipe to a cherry red, plunge it into water; then polish the end of your steel plug, place the key upon a plate of brass or copper, and hold it over your lamp with the blaze immediately under the pipe till the polished part becomes blue. Let cool gradually, then polish again. Blue and cool a second time, and the work will be done.

To Draw the Temper from Part of a Small Steel Article.—Hold the part from which you wish to draw the temper, with a pair of tweezers, and with your blow-pipe direct the flame upon them—not the article—till sufficient heat is communicated to the article to produce the desired effect.

To Blue Screws Evenly.—Take an old watch barrel and drill as many holes into the head of it as you desire to blue screws at a time. Fill it about one-fourth full of brass or iron filings, put in the head, and then fit a wire, long enough to bend over for a handle, into the arbor holes—head of the barrel upwards. Brighten the heads of your screws, set them, point downwards, into the holes already drilled, and expose the bottom of the barrel to your lamp till the screws assume the color you wish.

To Remove Blueing from Steel.—Immerse in a pickle composed of equal parts muriatic acid and elixir vitriol. Rinse in pure water and dry in tissue paper.

To Make Diamond Broaches.—Make your broaches of brass the size and shape you desire; then, having oiled them slightly, roll their points into fine diamond dust till entirely covered. Hold them then on the face of your anvil and tap with a light hammer till the grains disappear in the brass. Great caution will be necessary in this operation. Do not tap heavy enough to flatten the broach. Very light blows are all that will be required; the grains will be driven in much sooner than one would imagine.

Some roll the broach between two smooth pieces of steel to imbed the diamond dust. It is a very good way, but somewhat more wasteful of the dust.

Broaches made on this plan are used for dressing out jewels.

To Make Polishing Broaches.—These are usually made of ivory, and used with diamond dust, loose, instead of having been driven in. You oil the broach lightly, dip it into the finest diamond dust and proceed to work into the jewel the same as you do the brass broach. Unfortunately, too many watchmakers fail to attach sufficient importance to the polishing broach. The sluggish motion of watches now-a-days, is more often attributable to rough jewels than to any other cause.

To Make Diamond Files.—Shape your file of brass, and charge with diamond dust, as in the case of the mill. Grade the dust in accordance with the coarse or fine character of the file desired.

To Make Pivot Files.—Dress up a piece of wood file-fashion, about an inch brood, and glue a piece of fine emery paper upon it. Shape your file then, os you wish it, of the best cast steel, and before tempering pass your emery paper heavily across it several times, diagonally. Temper by heating to a cherry red, and, plunging into linseed oil. Old worn pivot files may be made over and made new by this process. At first thought one would be led to regard them too slightly cut to work well, but not so. They dress a pivot more rapidly than any other file.

To Make Burnishers.—Proceed the same as in making pivot files, with the exception that you are to use fine flour of emery on a slip of oiled brass or copper, instead of the emery paper. Burnishers which have become too smooth may be improved vastly with the flour of emery as above without drawing the temper.

To Prepare a Burnisher for Polishing.—Melt a little beeswax on the face of your burnisher. Its effect then, on brass or other finer metals, will be equal to the best buff. A small burnisher prepared in this way is the very thing with which to polish up watch wheels. Rest them on a piece of pith while polishing.

To Clean a Clock.—Take the movement of the clock "to-pieces." Brush the wheels and pinions thoroughly with a stiff, coarse brush; also the plates into which the trains work. Clean the pivots well by turning in a piece of cotton cloth held tightly between your thumb and finger, The pivot holes in the plates are generally cleansed by turning a piece of wood in them, but I have always found a strip of cloth or a soft cord drawn lightly through them to act the best. If you use two cords, the first one slightly oiled, and the next dry to clean the oil out, all the better. Do not use salt or acid to clean your clock—it can do no good, but may do a great deal of harm. Boiling the movement in water, as some practice, is also foolishness.

To Bush.—The hole through which the great arbors or winding axles work, are the only ones that usually require bushing. When they have become too much worn the great wheel on the axle before-named strikes too deeply into the pinions above it, and stop the clock. To remedy this bushing is necessary, of course. The most common way of doing it is to drive a steel point or punch into the plate just above the axle hole, thus forcing the brass downward until the hole is reduced to its original size. Another mode is to solder a piece of brass upon the plate in such a position as to hold the axle down to its proper place. If you simply wish your clock to run, and have no ambition to produce a bush that will look workmanlike, about as good a way as any is to fit a piece of hard wood beetween the post which comes through the top of the plate and the axle. Make it long enough to hold the axle to its proper place, and so that the axle will run on the end of the grain. Cut notches where the pivots come through, and secure by wrapping around it and the plate a piece of small wire, or a thread. There is no post coming through above the axle on the striking side. but this will rarely require bushing. I have known clocks to run well on this kind of bushing, botchified as it may appear, for ten years.

To Remedy Worn Pinions.—Turn the leaves or rollers so the worn places upon them will be towards the arbor or shaft, and fasten them in that position. If they are "rolling pinions," and you cannot secure them otherwise, you had better do it with a little soft solder.

To Oil Properly.—Oil only, and very lightly, the pallets of the verge, the steel pin upon which the verge works, and the point where the loop of the verge wire works over the pendulum wire. Use none but the best watch oil. Though you might be working constantly at the clock repairing business, a bottle costing you but 25 cents, would last you two years at least. You can buy it at any watch-furnishing establishment.

To Make the Clock Strike Correctly.—If not very cautious in putting up your clock you will get some of the striking-train wheels in wrong, and thus produce a derangement in the striking. If this should happen, pry the plates apart on the striking side, slip the pivots of the upper wheels out, and having disconnected them from the train, turn them part around and put them back. If still not right, repeat the experiment. A few efforts at most will get them to working properly.

A Defect to Look After.—Always examine the pendulum-wire at the point where the loop of the verge wire works over it. You will generally find a small notch, or at least a rough place worn there. Dress it out perfectly smooth, or your clock will not be likely to work well. Small as this defect may seem, it stops a large number of clocks.

To Refine Gold.—If you desire to refine your gold from the baser metals, swedge or roll it out very thin, then cut into narrow strips and curl up so as to prevent its lying flatly. Drop the pieces thus prepared into a vessel containing good nitric acid, in the proportion of acid 2 oz., and pure rain water ½ oz. Suffer to remain until thoroughly dissolved, which will be the case in ½ hour to 1 hour. Then pour off the liquid carefully and you will find the gold in the form of a yellow powder lying at the bottom of the vessel. Wash this with pure water till it ceases to have an acid taste, after which you may melt and cast into any form you choose. Gold treated in this way may be relied on as perfectly pure.

In melting gold use none other than a charcoal fire, and during the process sprinkle saltpetre and potash into the crucible occasionally. Do not attempt to melt with stone coal, as it renders the metal brittle and otherwise imperfect.

To Refine Silver.—Dissolve in nitric acid as in the case of the gold. When the silver has entirely disappeared, add to the water. Sink, then, a sheet of clean copper into it—the silver will collect rapidly upon the copper, and you can scrape it off and melt into bulk at pleasure.

In the event you were refining gold in accordance with the foregoing formula, and the impurity was silver, the only steps necessary to save the latter would be to add the above-named proportion of water to the solution poured from the gold, and then to proceed with your copper plate as just directed.

To Refine Copper.—This process differs from the one employed to refine silver in no respects save the place to be immersed; you use an iron instead of a copper plate to collect the metal.

If the impurities of gold refined were both silver and copper, you might, after saving the silver as above directed, sink your iron plate into the solution yet remaining, and take out the copper. The parts of alloyed gold may be separated by these processes, and leave each in a perfectly pure state.

To Hard Solder Gold, Silver, Copper, Brass, Iron, Steel, or Platina.—The solders to be used for gold, silver, copper and brass are given in the preceding part. You commence operations by reducing your solder to small particles and mixing it with powdered sal-ammoniac and powdered borax in equal parts, moistened to make it hold together. Having fitted up the joint to be soldered, you secure the article upon a piece of soft charcoal, lay your soldering mixture immediately over the joint, and then with your blow pipe turn the flames of your lamp upon it until fusion takes place. The job is then done and ready to be cooled and dressed up.

Iron is usually soldered with copper or brass, in accordance with the above process. The best solder for steel is pure gold or pure silver, though gold or silver solders are often used successfully.

Platina can only be soldered well with gold; and the expense of it, therefore, contributes to the hindrance of a general use of platina vessels, even for chemical purposes, where they are of so much importance.

To Soft Solder Articles.—Moisten the parts to be united with soldering fluid; then, having joined them together, lay a small piece of solder upon the joint and hold over your lamp, or direct the blaze upon it with your blow pipe until fusion is apparent. Withdraw them from the blaze immediately, as too much heat will render the solder brittle and unsatisfactory. When the parts to be joined can be made to spring or press against each other, it is best to place a thin piece of solder between them before exposing to the lamp.

Where two smooth surfaces are to be soldered one upon the other, you may make an excellent job by moistening them with the fluid, and then, having placed a sheet of tin foil between them, holding them pressed firmly together over your lamp till the foil melts. If the surfaces fit nicely a joint may be made in this way so close as to be almost imperceptible. The brightest looking lead which comes as a lining to tin boxes works better in the same way than tin foil.

To Cleanse Gold Tarnished in Soldering.—The old English mode was to expose all parts of the article to a uniform heat, allow it to cool and then boil until bright in urine and sal-ammoniac. It is now usually cleansed with diluted sulphuric acid. The pickle is made in about the proportion of one-eighth of an oz. acid to 1 oz. rain water.

To Cleanse Silver Tarnished in Soldering.—Some expose to a uniform heat, as in the case of gold, and then boil in strong alum water. Others immerse for a considerable length of time in a liquid made of ½ an oz. of cyanuret potassa to 1 pt. rain water, and then brush off with prepared chalk.

To Make Gold Solution for Electro-Plating.—Dissolve five pennyweights gold coin, five grains pure copper and 4 grains pure silver in 3 oz. nitro muriatic acid; which is simply two parts muriatic acid and one part nitric acid. The silver will not be taken into solution as are the other two metals, but will gather at the bottom of the vessel. Add 1 oz. pulverized sulphate of iron, ½ oz. pulverized borax, 25 grs. pure table salt, and 1 qt. hot rain water. Upon this the gold and copper will be thrown to the bottom of the vessel with the silver. Let stand till fully settled, then pour off the liquid carefully, and refill with boiling rain water as before Continue to repeat this operation until the precipitate is thoroughly washed; or, in other words, fill up, let settle, and pour off so long as the accumulation at the bottom of the vessel is acid to the taste.

You now have about an eighteen carat chloride of gold. Add to it an oz. and an eighth cyanuret potassa, and 1 qt. rain water—the latter heated to the boiling point. Shake up well, then let stand about twenty-four hours and it will be ready for use.

Some use platina as an alloy instead of silver, under the impression that plating done with it is harder. I have used both, but never could see much difference.

Solution for a darker colored plate to imitate Guinea gold may be made by adding to the above 1 oz. of dragon's blood and five grains of iodide of iron.

If you desire an alloyed plate, proceed as first directed, without the silver or copper, and with an oz. and a half of sulphuret potassa in place of the iron, borax and salt.

To Make Silver Solution for Electro-Plating.—Put together into a glass vessel, one oz. good silver, made thin and cut into strips; two oz. best nitric acid and ½ an oz. pure rain water. If solution does not begin at once, add a little more water—continue to add a very little at a time till it does. In the event it starts off well, but stops before the silver is fully dissolved, you may generally start it up again all right by adding a little more water.

When solution is entirely effected, add 1 qt. warm rain water and a large tablespoonful of table salt. Shake well and let settle, then proceed to pour off and wash through other waters as in the case of the gold preparation. When no longer acid to the taste, put in an oz. and an eighth cyanuret potassa and a qt. pure rain water; after standing about twenty-four hours it will be ready for use.

To Plate with a Battery.—If the plate is to be gold, use the gold solution for electroplating; if silver use the silver solution. Prepare the article to be plated by immersing it for several minutes in a strong lye made of potash and rain water, polishing off thoroughly at the end of the time with a soft brush and prepared chalk. Care should be taken not to let the fingers come in contact with the article while polishing, as that has a tendency to prevent the plate from adhering—it should be held in two or three thicknesses of tissue paper.

Attach the article, when thoroughly cleansed, to the positive pole of your battery, then affix a piece of gold or silver, as the case may be, to the negative pole, and immerse both into the solution in such a way as not to hang in contact with each other.

After the article has been exposed to the action of the battery about ten minutes, take it out and wash or polish over with a thick mixture of water and prepared chalk or jeweller's rouge. If, in the operation, you find places where the plating seems inclined to peel off, or when it has not taken well, mix a little of the plating solution with prepared chalk or rouge, and rub the defective part thoroughly with it. This will be likely to set all right.

Govern your time of exposing the article to the battery by the desired thickness of the plate. During the time it should be taken out and polished up as just directed about every ten minutes, or as often at least as there is an indication of a growing darkness on any part of its surface. When done, finish with the burnisher on prepared chalk and chamois skin, as best suits your taste and convenience.

In case the article to be plated is iron, steel, lead, pewter, or block tin, you must, after first cleansing with the lye and chalk, prepare it by applying with a soft brush—a camel's hair pencil is best suited—a solution made of the following articles in the proportion named: Nitric acid, half an ounce; muriatic acid, one-third of an ounce; sulphuric acid, one-ninth of an ounce; muriate of potash, one-seventh of an ounce; sulphate of iron, one-fourth of an ounce; sulphuric ether, one-fifth of an ounce, and as much sheet zinc as it will dissolve. This prepares a foundation, without which the plate would fail to take well, if at all.

To Make Gold Amalgam.—Eight parts of gold and one of mercury are formed into an amalgam for plating, by rendering the gold into thin plates, making it red hot and then putting it into the mercury while the latter is also heated to ebullition. The gold immediately disappears in combination with the mercury, after which the mixture may be turned into water to cool. It is then ready for use.

To Plate With Gold Amalgam.—Gold amalgam is chiefly used as a plating for silver, copper, or brass. The article to be plated is washed over with diluted nitric acid or potash lye and prepared chalk, to remove any tarnish or rust that might prevent the amalgam from adhering. After having been polished perfectly bright, the amalgam is applied as evenly as possible, usually with a fine scratch brush. It is then set upon a grate over a charcoal fire, or placed into an oven and heated to that degree at which mercury exhales. The gold, when the mercury has evaporated, presents a dull yellow color. Cover it with a coating of pulverized nitre and alum in equal parts, mixed to a paste with water, and heat again till *it* is thoroughly melted, then plunge into water. Burnish up with a steel or bloodstone burnisher.

To Make and Apply Gold Plating Solution.—Dissolve half an ounce of gold amalgam in one ounce of nitro-muriatic acid. Add two ounces of alcohol, and then, having brightened the article in the usual way, apply the solution with a soft brush. Rinse and dry in saw-dust, or with tissue paper, and polish up with chamois skin.

To Make and Apply Gold Plating Powders.—Prepare a chloride of gold the same as for plating with a battery. Add to it, when thoroughly washed out, cyanuret potassa in the proportion of two ounces to five pennyweights of gold. Pour in a pint of clean rain water, shake up well and then let stand till the chloride is dissolved. Add then one pound of prepared Spanish whiting and let evaporate in the open air till dry, after which put away in a tight vessel for use. To apply it you prepare the article in the usual way, and having made the powder into a paste with water, rub it upon the surface with a piece of chamois skin or cotton flannel.

An old mode of making a gold plating powder was to dip clean linen rags into solution prepared as in the second article preceding this, and having dried, to fire and burn them into ashes. The ashes formed the powder, and were to be applied as above.

To Make and Apply Silver Plating Solution.—Put together in a glass vessel one ounce nitrate of silver, two ounces cyanuret potassa, four ounces prepared Spanish whiting, and ten ounces pure rain water. Cleanse the article to be plated as per preceding directions, and apply with a soft brush. Finish with the chamois skin or burnisher.

To Make and Apply Silver Plating Powder.—Dissolve silver in nitric acid by the aid of heat; put some pieces of copper into the solution to precipitate the silver; wash the acid out in the usual way; then with fifteen grains of it mix two drachms of tartar, two drachms of table salt, and half a drachm of pulverized alum. Brighten the article to be plated with lye and prepared chalk, and rub on the mixture. When it has assumed a white appearance, expose to heat as in the case of plating with gold amalgam, then polish up with the burnisher or soft leather.

To Frost Watch Movments.—Sink that part of the article to be frosted for a short time in a compound of nitric acid, muriatic acid and table salt—one ounce of each. On removing from the acid, place it in a shallow vessel containing enough sour beer to merely cover it; then with a fine scratch brush scour thoroughly, letting it remain under the beer during the operation. Next wash off, first in pure water and then in alcohol. Gild or silver in accordance with any recipe in the chapter on plating.

To Enamel Gold and Silver.—Take half a pennyweight of silver, two pennyweights and a half of copper, three pennyweights and a half of lead, and two pennyweights and a half of muriate of ammonia. Melt together and pour into a crucible with twice as much pulverized sulphur; the crucible is then to be immediately covered that the sulphur may not take fire, and the mixture is to be calcined over a smelting fire until the superfluous sulphur is burned away. The compound is then to be coarsely pounded, and with a solution of muriate of ammonia to be formed into a paste which is to be placed upon the article it is designed to enamel. The article must then be held over a spirit lamp till the compound upon it melts and flows. After this it may be smoothed and polished up in safety. This makes the black enamel now so much used on jewelry.

To Destroy the Effects of Acid on Clothes.—Dampen as soon as possible after exposure to the acid with spirits ammonia. It will destroy the effect immediately.

To Wash Silver Ware.—Never use a particle of soap on your silverware, as it dulls the lustre, giving the article more the appearance of pewter than silver. When it wants cleaning rub it with a piece of soft leather and prepared chalk, the latter made into a kind of paste with pure water, for the reason that water not pure might contain gritty particles.

To Cleanse Brushes.—The best method of cleansing watchmakers' and jewelers' brushes is to wash them out in strong soda water. When the backs are wood you must favor that part as much as possible, for, being glued, the water might injure them.

To Cut Glass Round or Oval Without a Diamond.—Scratch the glass around the shape you desire with the corner of a file or graver; then, having bent a piece of wire in the same shape, heat it red hot and lay it upon the scratch, sink the glass into cold water just deep enough for the water to come almost upon a level with its upper surface. It will rarely ever fail to break perfectly true.

To Re-Black Clock Hands.—Use asphaltum varnish. One coat will make old rusty hands look as good as new, and it dries in a few minutes.

Improved Wood Filing Composition. — Japan, ½ pt.; boiled linseed oil, ½ pt.; turpentine, ½ pt.; starch, 6 oz. Mix *well* together and apply to the wood. On walnut wood add a little burned umber, on cherry a little Venetian red, to the above mixture.

Planing Metals.—The first operation about planing is to oil your planer and find out if the bed is smooth. If it is not file off the rough places; then change the dogs to see if they will work well, and find out the movements of the planer. After doing this, bolt your work on to the bed, and if it is a long, thin piece, plane off a chip, then turn it over and finish the other side, taking two chips, the last of which should be very light. Great care should be taken in bolting the bed not to spring it. After finishing this side turn it to the other side, and take off a light cut to finish it.

Planing Perpendicularly.—In planing perpendicularly, it is necessary to swivel the bottom of the small head around, so it will stand about three-fourths of an inch inside of square, towards the piece you are to plane. This prevents breaking the tool when the bed runs back.

Gear Cutting.—In cutting gears, they are reckoned on a certain number of teeth to the inch, measuring across the diameter to a certain line which is marked on the face or sides of the gear with a tool. This line is one-half the depth of the teeth from the outer diameter. That is, if the teeth of the gear are two-tenths of an inch deep, this line would be one-tenth of an inch from the edge, and is called the pitch line.

Depth of Teeth.—Every gear cut with a different number of teeth to the inch, should be cut of a depth to the pitch line, to correspond with the number of teeth to the inch. This is called proportion. Therefore, if you cut a gear eight to the inch, the depth to the pitch line should be one-eighth of an inch, and the whole depth of the tooth would be two-eighths. Again, if you cut a gear twelve to the inch, the depth to pitch line should be one-twelfth of an inch, and the whole depth of tooth two-twelfths. And again, if you cut a gear twenty to the inch, the depth to pitch line should be one-twentieth of an inch, while the whole depth should be two-twentieths, and so on *ad infinitum.*

Measuring to find the Number of Teeth.—To find the size a certain gear should be, for a certain number of teeth, is an easy matter if you study carefully these rules. If you want a gear with thirty-two teeth and eight to the inch, it should be four inches, measuring across the diameter to the pitch line, and the two-eighths outside of the pitch line would make it four inches and two-eighths. Again, if you want a gear with forty teeth, and ten to the inch, it should measure across the diameter to pitch line four inches, and the two-tenths outside the pitch line would make the whole diameter four inches and two-tenths. And again, if you want a gear with eighty teeth, and twenty to the inch, it should measure to the pitch line, across the diameter, four inches, and the two-twentieths outside the pitch line would make it four inches and two-twentieths, and these examples will form a rule for the measurement of all except bevel gears.

Bevel Gears.—These are turned a certain bevel to correspond with each other, according to the angle upon which the shafts driven by them are set. For instance, if two shafts are set upon an angle of ninety degrees, the surfaces of the faces of these gears will stand at an angle of forty-five degrees. To get the surface of these gears in turning them, put a straight edge across the face, then set your level on an angle of forty-five degrees, and try the face of the teeth by placing the level on a straight edge. After turning the face of the teeth, square the outer diameter by the face of the teeth: and to get the size to which you wish to cut, measure from the centre of the face of the teeth. Thus if a bevel gear is six inches in diameter, and the face of the teeth is one inch, you will measure from the centre of the face, and find it is five inches. On this line you calculate the number of teeth to the inch, and if you want a gear with twenty teeth, and ten to the inch, it should measure two inches across the face to the centre of the surface of the teeth; and if the face of the teeth were one inch in length, the diameter of the gear would be three inches, and the inside of the teeth would measure only one inch. Again if you want to cut a gear with forty teeth, and ten to the inch, it would measure four inches to the centre of the teeth on the surface. And if the surface of the teeth were one inch long, the diameter of the gear would be five inches, while it would only measure three inches inside the teeth. These examples will form a rule for all bevel gear.

Draw-Filing and Finishing.—To draw-file a piece of work smoothly and quickly, it is best to first draw-file it with a medium fine file, and finish with a superfine file. After doing this, polish the work with dry emery paper, and then with emery paper and oil.

Lining Boxes with Babbitt Metal.—To line boxes properly, so as to insure their filling every time, it is necessary to heat the box nearly red hot, or at least hot enough to melt the metal. Then smoke the shaft where the metal is to be poured upon it. This insures its coming out of the box easily, after it is cold. After smoking the shaft, put it into the box or boxes, and draw some putty around the ends of them, for the purpose of stopping them, taking care not to press upon it, for if you do it will go into the box, and fill a place that ought to be filled with metal; and in the meantime your metal ought to be heated, and after you have poured it, let the box stand till it is nearly cold; drive out your shaft, and it is done.

Making Lining Metal.—Melt in a crucible one and a half pounds of copper, and while the copper is melting, melt in a ladle twenty-five pounds of tin, and three of antimony, nearly red hot, pour the two together, and stir until nearly cool. This makes the finest kind of lining metal.

Putting Machines Together.—In putting machines together no part should be finished except where it is necessary to make a fit, as it is sometimes the case that machinery is miscalculated, and by finishing it would be spoiled, while if it were not it might be saved by slight alterations in design. And again, in finishing certain parts before you get a machine together, you are unknowingly finishing parts not necessary to be finished, and making them of a shape anything but desirable. This rule, however, is not intended to apply to machinery being made to detail drawings.

To Drill a Hole where you have no Reamer.—It is sometimes necessary to drill a hole of an exact size to fit a certain shaft, and at the same time have it smooth without reaming it. This may be done, by first drilling a hole, a one-hundredth of an inch smaller than the size desired, and then making a drill the exact size and running it through to finish with. This last drill should have the corners of its lips rounded, like a reamer, and the hole should be finished without holding the drill with a rest.

Boring a Hole with a Boring Tool.—In boring a hole with a boring tool, it is usually necessary to drill the hole first, and too much care cannot be taken in finishing. An iron gauge should be made first; is usually made of a piece of sheet iron or wire. The hole should then be drilled smaller than the size desired, and then bored to the required size, and it is impossible to bore a hole perfect without taking two or three light chips, mere scrapings with which to finish. Holes, in this way, may be bored as nicely as they can be reamed.

Squaring or Facing up Cast Iron Surfaces.—A round end tool is best for this. A rough chip should first be taken off, over the entire surface to be faced. Then speed your lathe up and taking a light chip, merely enough to take out the first tool marks, run over the entire surface again. In turning up surfaces it is always best to begin at the centre and feed out, as the tool cuts freer and will wear twice as long.

Boring Holes with Boring Arbor.—A boring arbor is a shaft with a steel set in it, for the purpose of boring holes of great length, and is designed to be used in a lathe. In doing this properly, you must first see if your lathe is set straight. If not, adjust it; having done this, put the piece of work to be bored in the carriage of your lathe, pass your arbor through the hole to be bored, and put it on the centres of your lathe. Having done this, adjust your work true to the position desired by measuring from the point of the tool, continually turning round the arbor from side to side of the piece to be bored, while you are bolting it to the carriage, and measure until it is perfectly true. Having done this, bore the hole, and take for the last chip only a hundredth of an inch. This makes a true and smooth hole. It is impossible to make a hole true with any kind of a tool when you are cutting a large chip, for the tool springs so that no dependence can be placed upon it.

To make a Boring Arbor and Tool that will not Chatter.—Boring tools, when used in small arbors, are always liable to chatter and make a rough hole. To prevent this, the tool should be turned in a lathe, while in its position in the arbor, upon the circle of the size of the hole to be bored, and the bearing lengthwise of the arbor should be only as wide as the feed of the lathe; for if the bearing of the tool is on the face, the more it will chatter.

CEMENTS.

[See other pages also.]

Rust Joint.—Quick Setting.—1 lb. sal ammoniac in powder, 2 lbs. of flour of sulphur, 80 lbs. iron borings. Made to a paste with water. Slow Setting.—2 lbs. sal ammoniac, 1 lb. of sulphur, 200 lbs. iron borings. This latter cement is best if the joint is not required for immediate use.

For Steam Boilers, Steam Pipes, Etc.—Soft.—Red or white lead in oil, 4 parts; iron borings, 2 to 3 parts. Hard.—Iron borings and salt water, and a small quantity of sal ammoniac with fresh water.

Maltha, or Greek Mastic.—Lime and sand mixed in the manner of mortar, and made into a proper consistency with milk or size without water.

For China.—Curd of milk, dried and powdered, 10 oz.; quicklime, 1 oz.; camphor, 2 drachms. Mix, and keep in closely stopped bottles. When used, a portion is to be mixed with a little water into a paste.

For Earthen and Glassware.—Heat the article to be mended a little above 212°, then apply a thin coating of gum shellac upon both surfaces of the broken vessel. Or, dissolve gum shellac in alcohol, apply the solution, and bind the parts firmly together until the cement is dry.

Holes in Casting.—Sulphur in powder, 1 part; sal ammoniac, 2 parts; powdered iron turnings, 80 parts. Make into a thick paste. The ingredients composing this cement should be kept separate, and not mixed until required for use.

For Marble.—Plaster of Pasis, in a saturated solution of alum, baked in an oven, and reduced to powder. Mixed with water. It may be mixed with various colors.

For Marble Workers and Coppersmiths. — White of egg, mixed with finely sifted quicklime, will unite objects which are not submitted to moisture.

Transparent for Glass.—India rubber, 1 part in 64 of chloroform; add gum mastic in powder, 16 to 24 parts. Digest for two days with frequent shaking.

To Mend Iron Ware.—Sulphur, 2 parts; fine black lead, 1 part. Put the sulphur in an iron pan, over a fire, until it melts, then add the lead; stir well; then pour out. When cool, break into small pieces. A sufficient quantity of this compound being placed upon the crack of the ware to be mended, can be soldered by an iron.

For Cisterns and Water Casks.—Melted glue, 8 parts; linseed oil, 4 parts; boiled into a varnish with litharge. This cement hardens in about 48 hours, and renders the joints of wooden cisterns and casks air and water tight.

Hydraulic Cement Paint.—Hydraulic cement mixed with oil forms an incombustible and waterproof paint for roofs of buildings, out-houses, walls, etc.

Entomologists' Cement.—Thick mastic varnish and isinglass size, equal parts.

BROWNING.

[See other pages also.]

Browning, or Bronzing Liquid. — Sulphate of copper, 1 oz.; sweet spirit of nitre, 1 oz.; water, 1 pint. Mix. In a few days it will be fit for use.

Browning for Gun Barrels.—Tinct. of mur. of iron, 1 oz.; nitric ether, 1 oz.; sulphate of copper, 4 scruples; rain water, 1 pint. If the process is to be hurried, add 2 or 3 grains of oxymuriate of mercury. When the barrel is finished, let it remain a short time in lime water, to neutralize any acid which may have penetrated; then rub it well with an iron wire scratch brush.

Hardening Compound used in Damascus Sword Blades.—The blade is covered with a paste formed of equal parts of barilla, powdered egg-shells, borax, common salt, and crude soda; heated to a moderate red heat, and just as the red is turning to a black heat, quench it in spring water.

LACKERS.

For Small Arms, or Waterproof Paper.—Beeswax, 13 lbs.; spirits of turpentine, 13 gallons; boiled linseed oil, 1 gallon. All the ingredients should be pure and of the best quality. Heat them together, in a copper or earthen vessel over a gentle fire, in a water-bath, until they are well mixed.

For Bright Iron Work.—Linseed oil, boiled, 80.5; litharge, 5.5; white lead, in oil, 11.25; resin, pulverized, 2.75. Add the litharge to the oil; let it simmer over a slow fire 3 hours; strain it, and add the resin and white lead; keep it gently warmed, and stir it until the resin is dissolved.

INKS.

Indelible, for Marking Linen, Etc.—1. Juice of sloes, 1 pint; gum, ½ an ounce. This requires no "preparation" or mordant, and is very durable. 2. Nitrate of silver, 1 part; water, 6 parts; gum, 1 part. Dissolve. MARKING.—Lunar caustic, 2 parts; sap green and gum arabic, each 1 part; dissolve with distilled water. THE "PREPARATION."—Soda, 1 ounce; water, 1 pint; sap green, ½ drachm. Dissolve, and wet the article to be marked, then dry and apply the ink.

PERPETUAL, FOR TOMB STONES, MARBLE, ETC.—Pitch, 11 parts; lampblack, 1 part; turpentine sufficient. Warm and stir.

COPYING INK.—Add 1 oz. of sugar to a pint of ordinary ink.

GLUES.

[See other pages also.]

For Parchment.—Parchment shavings, 1 lb.; water, 6 quarts. Boil until dissolved, then strain and evaporate slowly to the proper consistence.

Rice Glue, or Japanese Cement.—Rice flour; water, sufficient quantity. Mix together cold, then boil, stirring it all the time.

Liquid.—Glue, water, and vinegar, each 2 parts. Dissolve in a water-bath, then add alcohol, 1 part. Or, cologne or strong glue, 2.2 lbs.; water, 1 quart; dissolved over a gentle heat; add nitric acid 36°, 7 oz., in small quantities. Remove from the fire and cool. Or, white glue, 16 oz.; white lead, dry, 4 oz.; rain water, 2 pints. Add alcohol, 4 oz., and continue the heat for a few minutes.

Marine.—Dissolve India-rubber, 4 parts, in 34 parts of coal-tar naphtha; add powdered shellac, 64 parts. While the mixture is hot it is poured upon metal plates in sheets. When required for use, it is heated, and then applied with a brush. Or, 1 part India-rubber, 12 parts of coal-tar; heat gently, mix, and add 20 parts of powdered shellac. Pour out to cool. When used, heat to about 250°. Or, glue, 12 parts; water, sufficient to dissolve; and yellow resin, 3 parts; and, when melted, add turpentine, 4 parts. Mix thoroughly together.

STRONG GLUE.—Add powdered chalk to common glue.

GUM MUCILAGE.—A little oil of cloves poured into a bottle containing gum mucilage, prevents it from becoming sour.

Glue to Resist Moisture.—5 parts glue, 4 parts resin, 2 parts red ochre, mixed with the least practicable quantity of water. Or, 4 parts of glue, 1 part of boiled oil by weight, 1 part oxide of iron. Or, 1 lb. of glue melted in 2 quarts of skimmed milk.

VARNISHES.

[See other pages also.]

Waterproof.—Flour of sulphur, 1 lb.; Linseed-oil, 1 gal.; boil them until they are thoroughly combined. This forms a good varnish for waterproof textile fabrics. Another is made of oxide of lead, 4 lbs.; lamp-black, 2 lbs.; sulphur, 5 oz.; and India-rubber dissolved in turpentine, 10 lbs. Boil together until they are thoroughly combined.

To Adhere Engravings or Lithographs upon Wood.—Sandarach, 250 parts; mastic in tears, 64; resin, 125; Venice turpentine, 250; and alcohol, 1000 parts by measure.

For Harness.—India-rubber, ½ lb.; spirits of turpentine, 1 gal.; dissolve into a jelly; then take hot linseed oil, equal parts with the mass, and incorporate them well over a slow fire.

For Fastening Leather on Top Rollers.—Gum Arabic, 2¾ oz., dissolved in water, .and a like volume of isinglass dissolved in water.

To Preserve Glass from the Rays of the Sun.—Reduce a quantity of gum tragacanth to fine powder, and let it dissolve for 24 hours in white of eggs well beat up.

For Water-Color Drawings.—Canada balsam, 1 part; oil of turpentine, 2 parts, mixed. Size the drawing before applying the varnish.

For Objects of Natural History, for Shells, Fish, &c.—Mucilage of gum tragacanth and mucilage of gum arabic, each 1 oz. Mix, and add spirit with corrosive sublimate, so as to precipitate the more stringy part of the gum.

For Articles of Iron and Steel.—Clear grains of mastic, 10 parts; camphor, 5 parts; sandarach, 15 parts; and elemi, 5 parts. Dissolve in a sufficient quantity of alcohol, and apply without heat. This varnish will retain its transparancy, and the metallic brilliancy of the article will not be obscured.

For Gun Barrels, after Browning.—Shellac, 1 oz.; Dragon's blood, ¼ oz.; rectified spirit, 1 quart. Dissolve and filter.

Black.—Heat to boiling, 10 parts of linseed oil varnish with burnt umber, 2 parts, and powdered asphaltum, 1 part. When cooled, dilute with spirits of turpentine as required.

Balloon.—Melt India-rubber in small pieces with its weight of boiled linseed oil. Thin with oil of turpentine.

Transfer.—Alcohol, 5 oz.; pure Venice turpentine, 4 oz.; mastic, 1 oz.

To Clean Varnish.—Mix a lye of potash, or soda, with a little powdered chalk.

Composition for Rendering Canvas Waterproof and Pliable.—Yellow soap, 1 lb., boiled in 6 pints of water, add, while hot, to 112 lbs. of paint.

Good Painting requires 4 or 5 coats; but usually only 4 are used in principal rooms; and 3 in inferior ones. Each coat must be allowed to dry perfectly before the next one is put on. One lb. of the keg paint will, after being thinned, cover about 2 sq. yds. of first coat; 3 yds. of second; and 4 yds. of each subsequent coat; or 1 sq. yd. of 3 coats will require in all, 1·08 lbs.; of 4 coats, 1⅓ lbs.; of 5 coats, 1·58 lbs. The reason why the first coats require so much more than the subsequent ones, is that the bare surface of the wood absorbs it more.

Painting of Brick Work.—A square yard of new brick wall requires for the first coat of paint in oil, ¾ lb.; and for the second, ·3; and for the third, ·4.

MISCELLANEOUS.

To Clean Marble.—Chalk, powdered, and pumice-stone, each 1 part; soda, 2 parts. Mix with water. Wash the spots, then clean and wash off with soap and water.

To Extract Grease from Stone or Marble.—Soft soap, 1 part; Fuller's earth, 2 parts; potash, 1 part. Mix with boiling water. Lay it upon the spots, and let it remain for a few hours.

Paint for Window Glass.—Chrome green, ¼ oz.; sugar of lead, 1 lb.; ground fine, in sufficient linseed oil to moisten it. Mix to the consistency of cream, and apply with a soft brush. The glass should be well cleaned before the paint is applied. The above quantity is sufficient for about 200 feet of glass.

Durable Paste.—Make common flour paste rather thick (by mixing some flour with a little *cold* water until it is of uniform consistency, and then stir it well while *boiling* water is being added to it;) add a little brown sugar and corrosive sublimate, which will prevent fermentation, and a few drops of oil of lavender, which will prevent it becoming mouldy. When this paste dries, it may be used again by dissolving it in water. It will keep for two or three years in a covered vessel.

Dubbing.—Resin, 2 lbs.; tallow, 1 lb.; train-oil, 1 gallon.

Blacking for Harness.—Bees' wax, ½ lb.; ivory black, 2 oz.; spirits of turpentine, 1 oz.; Prussian blue ground in oil, 1 oz.; copal varnish, ¼ oz. Melt the wax and stir it into the other ingredients before the mixture is quite cold; make it into balls. Rub a little upon a brush, and apply it upon the harness, then polish lightly with silk.

To Prevent Iron from Rusting.—Warm it; then rub with white wax; put it again to the fire until the wax has pervaded the entire surface. Or, immerse tools or bright work in boiled linseed oil and allow it to dry upon them.

Paper for Draughtsmen, &c.—Powdered tragacanth, 1 part; water, 10 parts; dissolve, and strain through clean gauze, then lay it smoothly upon the paper, previously stretched upon a board. This paper will take either oil or water-colors.

To Remove Old Ironmould.—Remoisten the part stained with ink, remove this by the use of muriatic acid diluted by 5 or 6 times its weight of water, when the old and new stain will be removed.

Pastiles for Fumigating.—Gum arabic, 2 oz.; charcoal powder, 5 oz.; cascarilla bark, powdered ¾ oz.; saltpetre, ¼ drachm. Mix together with water, and make into shape.

For Writing Upon Zinc Labels—Horticultural.—Dissolve 100 gr. of chloride of platinum in a pint of water; add a little mucilage and lamp-black. Or, sal-ammoniac, 1 dr; verdigris, 1 dr.; lamp-back, ½ dr.; water, 10 drs. Mix.

Booth's Grease for Railway Axles.—Water, 1 gall,; clean tallow, 3 lbs.; palm oil, 6 lbs.; common soda, ½ lb.; or, tallow, 8 lbs.; palm oil, 10 lbs. To be heated to about 212°, and to be well stirred until it cools to 70°.

Anti-friction Grease.—100 lbs. tallow, 70 lbs. palm oil. Boiled together, and when cooled to 80°, strain through a sieve, and mix with 28 lbs. of Soda and 1½ gals. of water. For winter, take 25 lbs. more oil in place of the tallow. Or black lead, 1 part; lard, 4 parts.

Liard.—50 parts of finest rape oil and 1 part of caoutchouc, cut small. Apply heat until it is nearly all dissolved.

Stains.—To REMOVE—Stains of *Iodine* are removed by rectified spirit. *Ink* stains by oxalic or superoxalate of potash. *Ironmoulds* by the same; but if obstinate, moisten them with ink, then remove them in the usual way.

RED SPOTS upon black cloth from acids are removed by spirts of hartshorn, or other solutions of ammonia.

STAINS of MARKING-INK, OR NITRATE OF SILVER.—Wet the stain with fresh solution of cloride of lime, and after 10 or 15 minutes, if the marks have become white, dip the part in solution of ammonia or of hyposulphite of soda. In a few minutes wash with clean water. Or stretch the stained linen over a basin of hot water, and wet the mark with tincture of iodine.

Preservative Paste for Objects of Natural History.—White arsenic, 1 lb.; powdered hellebore, 2 lbs.

Paste for Cleaning Metals.—Oxalic acid, 1 part; rottenstone, 6 parts. Mix with equal parts of train oil and spirits of turpentine.

Watchmaker's Oil, which never Corrodes or Thickens.—Place coils of thin sheet lead in a bottle with olive oil. Expose it to the sun for a few weeks, and pour off the clear oil.

Blacking, Without Polishing.—Molasses, 4 oz.; lamp-black, ½ oz.; yeast, a tablespoonful; eggs, 2; olive oil, a teaspoonful; turpentine, a teaspoonful. Mix well. To be applied with a sponge, without brushing.

To Preserve Sails.—Slacked lime, 2 bushels. Draw off the lime water, and mix it with 120 gallons water, and with blue vitriol, ¼ lb.

Whitewash.—For outside exposure, slack lime, ½ a bushel, in a barrel; add common salt, 1 lb.; sulphate of zinc, ½ lb.; and sweet milk, 1 gal.

To Preserve Woodwork..—Boiled oil and finely powdered charcoal, each 1 part; mix to the consistence of paint. Lay on 2 or 3 coats with it. This composition is well adapted for casks, water-spouts, &c.

To Polish Wood.—Rub surface with pumice stone and water until the rising of the grain is removed. Then, with powdered tripoli and boiled linseed oil, polish to a bright surface.

To Clean Brass Ornaments.—Brass ornaments that have not been gilt or lackered may be cleaned, and a very brilliant color given to them, by washing them in alum boiled in strong lye, in the proportion of an ounce to a pint, and afterward rubbing them with strong tripoli.

Adhesive Cement for Fractures of all Kinds.—White lead ground with linseed oil varnish, and kept out of contact with the air. It requires a few weeks to harden. When stone or iron are to be cemented together, use a compound of equal parts of sulphur and pitch.

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